Essays on conflict, cooperation and economic development

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Abstract

This dissertation consists of three chapters on topics relating to conflict, social cooperation and development economics.

Several studies have identified the impact of adverse economic shocks on civil conflict using rainfall variation as an instrument for income or growth. The first chapter contributes to this literature by carrying out a micro-level analysis on the relationship between climate and resource variation with armed conflict using a novel dataset on inter-tribal violence manifested through livestock raids in a pastoral-dependent region of East African called the Karamoja. Consistent with previous work, I find that across the region there is a negative relationship between resources and conflict, when resources are measured with forage. However, I also find that both decreases and increases in rainfall are correlated with conflict across the region. This bimodal relationship between precipitation and conflict persists when I analyse raid-location and tribe specific variation in rainfall, while the relationship between forage and raiding is less clear. There is some indication that forage-scarcity motivates tribes to carry out raids and forage-scarce sublocations appear to be more vulnerable to raids and livestock losses, but these results are not robust to all specifications.

In the second chapter, I study the effect of Uganda's 2006 disarmament policy in the Karamoja region in East Africa. The disarmament policy greatly reduced the guns of tribes in the Ugandan districts of the region but not in the Kenyan districts. The theoretical impact of the disarmament is ambiguous, however, since guns can be used for deterrence as well as helping aggressors carry out violent crimes, such as livestock raiding. Empirically, I find that the disarmament campaign had the unintended effect of increasing the frequency of raids in Uganda by about 40%, while, consistent with the idea that disarmament reduced the costs of raiding, I find no impact on the monthly death rate. Moreover, the increase in raids in Uganda was driven by an increase in Ugandan initiated raids on other Ugandans, not an increase in Kenyan initiated raids on Ugandans, suggesting that within Uganda the deterrent effect of guns outweighs their impact as a tool of aggression.

In the third chapter, written jointly with Johannes Haushofer, we study the impact of stress on social behavior by exogenously stimulating the two biological systems associated with stress: the hypothalamus-pituitary-adrenal axis (HPA) and noradrenergic (NA) system and measuring behavior in interactive tasks in a laboratory experiment. Our preliminary findings suggest that the concurrent stimulation of both systems, through the administration of 60mg of hydrocortisone and 20mg of yohimbine, did not lead to statistically detectable changes to behavior in any of the social tasks. It did, however, manifest in lower opinions of the trustworthiness and fairness of other people, as well as a decrease in the value associated with helping other people, as measured through a visual analog scale survey. Given these initial results, we find preliminary evidence for a relationship between stress and anti-social behavior as revealed through lower beliefs on social standards.

JEL Classification: C91, K42, Q56

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Contents

List of Figures

List of Tables

Chapter 1

Conflict and Climate: a Micro-level Analysis

1.1 Introduction

Internal armed conflict is a prevalent issue in the modern world. Conflict events with at least 25 battle deaths per annum have occured in half of all nations since 1960 (Blattman and Miguel 2010 [15]).[1] Yet, the incidence of conflict is still somewhat of an economic puzzle: why do individuals, or groups, decide to engage in conflict, when it appears to be such a costly and rent destroying activity? Over the last two decades this puzzle has drawn significant academic attention, but according to a survey of the literature there is still little consensus on the most effective policies to avert conflicts, which may be due to a lack of micro-level analysis that focuses on causal identification of conflict (Blattman and Miguel 2010 [15]).

More recently, an expansive cross-disciplinary literature has emerged that examines the relationship between climatic changes and conflict, with particular attention to Sub-Saharan Africa. Sub-Saharan Africa has a history of civil conflict, political instability and non-state violence, with 74 of the 127 civil wars recorded between 1945-1999 and 112 of the 154 non-state conflicts recorded between 2002-2007 occurring in this part of the world (Harari and La Ferrara 2012 [39]

[1]These definitions come from the well-known UCDP-PRIO dataset developed by Nils Petter Gleditsch et al. (2002) and extended in Lotta Harbom and Peter Wallensteen (2007). UCDP-PRIO defines conflict as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths."

and UCDP Non-State Conflict Dataset v2.1 2002-2007 [96]). The region is also expected to face some of the worst consequences of climate change, as a large proportion of the population rely on weather dependent agricultural practices, such as growing rainfed crops and raising livestock, and the region is predicted to be particularly vulnerable to future climate changes. For example, estimates of aggregate yield changes for the five main rainfed crops in the region range between -8% and -22% over the next fifty years (Schlenker and Lobell 2010 [88]). Thus, a large body of research has emerged that attempts to establish whether there is a causal link between weather deviations and the propensity for conflict in the region, with most studies focusing on the impact negative weather shocks have on poverty.[2]

This study is able to contribute to both debates by analysing conflict at a micro-level and focusing on a region within Sub-Saharan Africa that is extremely vulnerable to weather fluctuations. I use a unique dataset that contains detailed information on conflict between tribes in the Karamoja region of East Africa. Moreover, this conflict arises during livestock raids, where tribes in the region attack each other with the intention of obtaining livestock. Since pastoralism is the dominant livelihood in the region, this type of conflict corresponds to resource appropriation, where the resources are the animals stolen during raids, and these resources (livestock), will fluctuate in quality and quantity with climatic variation in the region. For example, prolonged periods of low rainfall reduce the availability of forage for the animals, which will diminish their health and can lead to reductions in herd sizes. At the same time, my analysis will not exclude the possibility that climatic conditions may directly influence the ease at which livestock raids can be carried out. For example, other studies on pastoral conflict have suggested that vegetation coverage enables raiders to hide before ambushing their target, and surface water from rainfall makes tracking animals easier (Adano and Witsenburg 2005 [100]). Thus, what I hope to contribute is a thorough investigation of the spatial patterns of conflict over a relatively homogeneous region, where I can carefully consider if it is possible to identify the direction of conflict based on any differences in the climatic exposure between tribes. That is, as well as examining the location of conflict as it pertains to weather and

[2]This literature started with the seminal contribution by Miguel, Satyanath and Sergenti (2004) [68], and has since been followed by many other papers (see Hsiang, Burke and Miguel (2013) [42] for a recent review.

forage variation, I will examine the direction of conflict between tribes, based on differences in the availability of water and forage between their grazing areas.

This study has several advantages that I believe will help improve our understanding of how climate variation influences resource-related conflict in Sub-Saharan Africa, and elucidate our knowledge of the micro-level determinants of conflict at a more general level. First, is the data that I use for this study. The data comes from comes from CEWARN (Conflict Early Warning and Response Mechanism), an initiative that was set up by the Intergovernmental Authority on Development (IGAD) in 2003 to monitor, prevent escalation or mitigate the worst effects of violent conflicts. CEWARN collects detailed accounts of all episodes of pastoral conflict and crime in the Karamoja Cluster by using field monitors to record reports of all these incidents. These incident reports contain detailed information on where livestock raids occur,[3] the date of each raid, the number of people involved, the outcomes to human life and property (such as the number of livestock taken), and which tribes were involved (who was the initiator and who was the target).[4] In addition, I have gridded precipitation and forage data. The precipitation estimates are available for the Africa region (20W-55E, 40S-40N) on a 0.1 degree resolution (approximately 11km x 11km) from FEWSNET-Famine Early Warning Systems Network [102], and are based on daily rain gauge data and 6-hourly satellite images, while the forage data comes from a joint project between USAID and Texas A&M University that developed monthly estimates of the forage available for livestock at a 4km x 4km resolution in kg/hectare [93]. The forage data is estimated using satellite (NDVI) data but also uses a simulation model called PHYGROW that takes into account soil types and the demands of forage for different types of livestock, and the output of the model is then calibrated to data from around 430 monitoring sites. Thus, I am able to more precisely match the rainfall and forage conditions to the location of livestock raids, and I can attempt to match the forage and rainfall exposure of different tribes to their propensity to initiate and be a target of raids, using additional anthropological

[3]Up to the sublocation level in Kenya, the subcounty level in Uganda, and by the area of reporting of the field monitor in Ethiopia.

[4]The following tribal groups are recorded as being involved in raids. Within Ethiopia: Borana, Dassenech, Hamer, Mursi, Nyangatom, Toposa. Within Kenya: Kenyan Pokot, Central Turkana, Southern Turkana, Northern Turkana. Within Uganda: Bokora, Dodoth, Jie, Matheniko, Pian, Ugandan Pokot, Sabiny.

and sociological accounts of the traditional grazing areas of the different tribes.[5] No other study has yet used the CEWARN data at this level of detail, and I know of no other studies on conflict and climate variation that have been able to so closely tie climate exposure to the perpetrators and targets of violence. For example, studies that rely on national-level measures, may not capture the climate exposure relevant to those directly involved in conflict, and even the disaggregated analysis carried out at the spatial-level of detail of a 1 degree grid cell resolution (about 100km x 100km), such as Harari and La Ferrara 2012 [39] and O'Loughlin et al. 2012 [75], cannot as precisely tie climate exposure to conflict, as I can in this study.

The second advantage of this paper, is that I focus on a single geographic region and a relatively homogeneous type of conflict. This has the advantage over cross-country or within continent empirical studies in several respects. First, I am able to confidently control for time-varying region-specific trends that may confound cross-country or cross-region empirical studies. Second, within the Karamoja region livestock raiding is a relatively homogeneous form of conflict, more so I would argue, than a comparison of all types of conflict events, that many studies hope to understand when they use the combined PRIO/Uppsala Armed Conflict Location and Event (ACLED) dataset [82]. This dataset includes not only battles with more than 25 casualties, but also rebel recruitment, riots, and violence against civilians. Even when just battles or violence against civilians is considered, there is still a large amount of heterogeneity in this type of conflict, in terms of the length of conflict or the consequences on human lives. Thus, by focusing on livestock raiding, I hope to more robustly analyse the relationship between climate variation and one particular type of conflict.

The third advantage of this paper, is that my regression analysis accounts for both spatial and temporal correlation in livestock raiding and climate variation. As discussed by Harari and La Ferrara (2012), it is important to consider not only the immediate effects of climate variation on conflict in a particular location, but also the persistance of any effects, both across time and space. In addition, when dealing with highly disaggregated data, one needs to be cognisant of spatial correlation

[5]I use remotely sensed data on forage as a source of resource variation, since there is a significant amount of ecological evidence on a direct relationship between the carrying capacity of land (the numer of livestock that can be effectively grazed per unit of land) and remotely sensed vegetation data (Oesterheld et al. 1998 [73], Box et al. 1989 [17], Coe et al. 1975 [22], East 1984 [32], Hill and Donald 2003 [40]).

in the covariates, as well as serial correlation in the dependent variable and residuals. Another nuance of this analysis, is the dyadic approach I use to consider how differences in the availability of water and forage between the grazing areas of tribes' influences the direction of conflict, which requires careful modelling of the error covariance matrix. Thus, I use empirical approaches that best address these considerations, and I present my results in a systematic and structured fashion, to transparently demonstrate any sensitivity of my results to modelling assumptions.

My results suggest that across the region there is a bimodal relationship between conflict and precipitation, with more pastoral raids occurring when there is both very little and a lot of rainfall across the Karamoja region. A standard deviation increase in the average level of precipitation leads to an increase in raids per month of about 22%, and an increase in the proportion of land with no rainfall of 0.1 leads to a 4% increase in raids per month. A standard deviation decrease in average level of forage has no impact on the number of raids per month, but increases the number of deaths by 23% and the number of livestock stolen by 44%. Thus, at the aggregate level there is evidence of resource-scarcity leading to more conflict as well as wet weather improving the conditions for raiding.

When tribe specific and sublocation specific variation in resources is examined, the relationship between forage and raiding is less clear. There is some indication that forage-scarcity motivates tribes to carry out raids and forage-scarce sublocations appear to be more vulnerable to raids and livestock losses, but these results are not robust to all specifications. There is, however, a bimodal relationship between conflict and precipitation at the sublocation level, with a higher likelihood of raids occurring in the month following both very little and a lot of rainfall. The death rate is also higher in months with either very little or a lot of rainfall as well. At the tribe-dyad level, I find that tribes that have recently experienced very dry weather are more likely to initiate raids, steal more livestock, and be responsible for a larger number of pastoral deaths, but I do not find that extreme positive deviations of precipitation affect these outcomes.

Together these results suggest that conflict in the Karamoja region is correlated with extreme precipitation fluctuations in either a positive or negative direction. Forage-scarcity may also be a motivator for tribes to initiate raids, but this relationship is less clear. Thus, these results are consistent with raids occurring when tribes encounter the greatest marginal gains to raiding because they are resource-scarce, but they are also consistent with several other explanations, such as climatic conditions directly influencing the ease through which raids are carried out.

There are several caveats to this paper. Firstly, there is the question of external validity. While there are advantages in focusing on a single geographic area and a homogenous form of resource related conflict, such as the increased plausibility that if any systematic relationship between climate variation and conflict exists, it will be identified, there is the concern that these results lack the basis for generalization. Although, location and tribe dyad fixed effects will at least partially control for potential confounding factors, such as political, social and geographic considerations, there remains the concern that the relationship between climate variation and conflict that I find is Karamoja region specific and not relevant to other forms of conflict. I would argue that these results could have meaningful implications in helping us understand pastoral conflict in other regions, such as the Somalia Cluster, Ethiopia and Sudan. Regardless however, given the significant costs to human lifes in the Karamoja region due to pastoral conflict, this issue is worth attention, even if the results may have limited external validity.

The second caveat to this paper is the ease to which forage and precipitation fluctuations can be attributed to different tribes. Pastoralists practice a transhumance livelihood, whereby the tribes move livestock dependent on the availability and quality of grazing. Thus, while the tribes tend to move their livestock within a particular territory and do not often use the same grazing areas, I cannot exclude the possibility that at times different tribes will use the same area to graze their animals. In fact other research on pastoralists has reported that during dry periods households from different tribes may be closer together, aggregating in temporary camps nearer the remaining water sources (Mathew and Boyd 2011 [61] and Stites, Fries and Akabwai 2010 [92]). My approach is to present results both based on the imputed forage and precipitation measurements of each tribe involved in a raid, and the forage and precipitation measurements at the location of a raid. Thus, I first look for a tribe-relevant climate effect on the direction of conflict, and then I consider location-relevant climate effect on the incidence of conflict, in case the first channel cannot be determined.

This paper contributes to the burgeoning literature on climate and violent conflict. This literature emerged following the seminal work by Miguel, Satyanath and Sergenti (2004) that used negative rainfall fluctuations as an instrument for income shocks in Sub Saharan Africa to identify a causal relationship between income and conflict in a cross-country analysis. They demonstrated that the likelihood of conflict increases by one half following negative growth shocks of five percentage points [68]. Since this paper, the literature has had many recent contributions, with the focus turned not only to the impact weather has on income, mainly through agricultural revenue and wages, but also to the more direct impacts of weather variation on the logistics of conflict, state capacity to resist conflict, as well as other channels, such as migration and urbanization, food price volatility and human behavioral tendencies. For a comprehensive review of the literature, I refer you to Hsiang, Burke and Miguel (2013) [42], who assemble the 50 most rigorous quantitative studies from across the disciplines of archaeology, psychology, political science and economics. Their meta analysis reports that for each standard deviation change in climate towards more extreme rainfall the frequency of interpersonal violence rises by 4% and the frequency of intergroup conflict rises by 12%. This paper complements this literature by following similar methodological approaches to earlier studies, but uses a different source of conflict data that contains much more detailed information on the location of conflict and the groups involved in conflict.

Several other recent studies have examined the relationship between climate and pastoral conflict in the Horn of Africa [4], [3], [21], [61], [65], [72], [80], [81], [83], [87], [92]. Meier, Bond and Bond (2007) is the most closely related study to this paper, as they also use the CEWARN data [65]. They report finding no relationship between precipitation or forage and livestock raiding, but that increases in vegetation coverage, measured through NDVI, are associated with increases in the level of raiding. This paper is differs, through using a longer times series of the CEWARN data, 2004-2009, compared to 2004-2005, and examining the relationship between conflict and climate at a greater degree of spatial disaggregation, with greater attention to potential econometric concerns. For example, Meier, Bond and Bond analyze the data using a single geographic unit for Kenya, another unit for Ethiopia and four units for Uganda. Given this, they do not directly address the spatial impacts of either climate variation or spillovers in conflict across neighboring areas. Furthermore, their regression approaches do not correct for either spatial correlation or serial correlation in conflict, or control for seasonal patterns in conflict that may spuriously coincide with seasonal weather patterns, nor do they control for location fixed effects or systematic time trends in conflict across their data period.

Obtaining detailed information on pastoral conflict over an extended time period has been a constraint faced by most other studies, that tend to instead present qualitative analysis based on case studies and in depth field interviews. Karen Witsenburg, Wario R Adano and Tom Dietz, have contributed numerous articles, where they emphasize resource scarcity leads to a greater degree of cooperation and fewer livestock raids. For example, they report fewer deaths in the Marsabit District of Kenya in drought years than in wet years, using archival records and annual reports of government ministries [3]. In another article, they explain that the herders, "see droughts as difficult times when animals are weak, survival is hard and people are more inclined to stop fighting, patch up their differences, renegotiate access rules and rights, and reconcile to cooperate" [83]. However, they acknowledge that, "there are only a few thorough empirical works on the relationships between natural resources scarcity and pastoral conflicts based on long-term time-series data" [83].

In contrast to findings of Witsenburg, Adano and Dietz, a group of researchers at Tufts University, including Darlington Akabwai, Elizabeth Stites and Lorin Fries, have instead noted that in the Uganda Karamoja, conflict tends to erupt when different groups are more likely to be accessing resources in close proximity, which tends to occur during dry periods [92]. Akabwai, Fries and Stites, note that, "respondents within the study population did not state that conflict or insecurity was caused by tension over resources, competition in accessing resources, or resource scarcity. They did make clear, however, that conflict is most likely to occur in areas where natural resources are being accessed and utilized" [92]. Given these contrasting accounts, this study will help address the debate through presenting a structured empirical analysis using six years of pastoral conflict data for the entire the Karamoja region.

My research also relates to the theoretical literature on pastoral raiding. Mathew and Boyd (2011) study the Turkana of Kenya and discuss the extent to which livestock raids involve cooperation among large parties, providing detailed case study information on this effect [61]. Butler and Gates (2012) present a theoretical model that shows how increases in resources could lead to increases in the level of raiding, while also demonstrating that asymmetry in pastoral strength may lead to more conflict, with poorer groups focusing their efforts on raiding and not producing, while richer groups raid in retaliation [21]. This paper will complement this research by presenting a contest function model similar to Butler and Gates (2012), but I abstract from considering asymmetry in property rights between tribes, which is a focus of Butler and Gates' model. Through differences in resources alone, I demonstrate how weather variation may influence the fighting strength of each tribe as well as the rewards to fighting, making the direction of conflict ambiguous.

The remainder of this paper is organized as follows. Section one discusses in more detail the background of the geographic region I study and the type of violence prevalent in the region. Section two introduces a simple contest model framework to help motivate the empirical analysis. Section three describes the conflict and climate data and outlines the methodology of my empirical analysis. Section four presents results. And section five finishes with a discussion of the main findings from the study and their implications.

1.2 Background

The region I study for this analysis of conflict is the Karamoja Cluster - a region located across the borders of Uganda, Sudan, Ethiopia and Kenya, covering an area of 25,000 square miles and with a human population estimated between 1 and 1.6 million (see figure 1-1). Tribal communities populate the region and form the groups between which conflict occurs. In Uganda, most tribes belong to the Karamojong ethnic group, which can be further divided into the Dodoth, Jie, Pian, Matheniko and Bokora; in Kenya, the predominant tribal group are the Turkana; and an ethnic group known as the Pokot live in the southern parts of the Cluster across the Kenya-Uganda border. Within Ethiopia the following tribes are present: Borana, Dassenech, Hamer, Mursi, Nyangatom, Toposa (see figure 2-2) (Gartell 1985 [38], Quam 1997 [79], Gray et al. 1999 [86], Powell 2010 [78]). All the tribes from Kenya and Uganda are closely ethno-linguistically related and come from the same Aketer subdivision of the Eastern Nilotic linguistic group (Ethnologue 2011) [2]. Thus, they are linguistically intelligible to each other, and share much history and culture, which makes it unlikely that their animosity towards each other is rooted in primordial differences (Horowitz 1985 [41]).

The traditional livelihood, and that which is still practised today, is nomadic pastoralism whereby cattle and livestock are raised to provide a diet of milk and blood to their owners. This type of transhumance pastoralism is thought to be the most effective method of subsistence for the region, given the fragile nature of the ecosystem and the harsh and unpredictable climate of the semi-arid terrain (Gray et al. 1999 [86]; Little 1999 [54]). While some grain, such as sorghum and millet, may be grown in small amounts to supplement their diet, the pastoralists rely heavily on their livestock as their primary source of nutrition as well as a measure of wealth, through which important transactions, such as bride or gun purchases, are denominated (Mburu 2007 [62], Jabs 2010 [47]).

Conflict is not a new phenomenon in the region and the activity of livestock raiding has a strong cultural heritage. Traditionally groups of young men would obtain the blessing of elders from their tribe to go out and raid a neighboring tribe with the intention of bringing back additional livestock and mark their coming of age into manhood. However, in more recent years the cultural aspect of raiding appears to be less important as the frequency and ferocity of raiding has increased, with raiding being undertaken by bands of young men who have guns. While they still identify with their ethnic tribal group (i.e., they call themselves the Dodoth, or the Jie warriors), and they do not raid from their own tribe, they no longer seek permission from their tribe's elders, and spend much time away from the tribal communities, effectively as roaming criminals (Akabwai and Ateyo 2007) [4]. This suggests that raiding is an appropriation activity, and given the level of violence associated with it, livestock raiding provides a unique setting for conflict analysis.[6]

There is evidence of significant population increases in the region over the last fifty years, that can be attributed to a greater access to healthcare facilities due to the increased number of development projects active in the region. At the same time, there are limited opportunities for pastoralists to migrate out of the region due to both political containment of pastoralists' movements and the difficulties pastoralists face when trying to integrate into mainstream society, which holds strong prejudices against pastoralists (McCabe and Ellis 1987 [64], McCabe 1990 [63], Gray et al.

[6] Bevan 2008 [12] and the Small Arms Survey [1] report homicide rates of over 60 per 100,000, and my own data suggests estimates 50-60 per 100,000.

1999 [86], Kratli 2001 [50], Powell 2010 [78]). However, drought conditions prevailed in the years 1992, 1994, 1998, 2000, 2004, and 2010-11, and depleted livestock populations [78], effectively reducing the demand for young men to present within the tribal communities for animal husbandry, and creating an excess supply of male labor.

Statistical indicators for the region are suggestive of extreme poverty and deprivation. An estimated 82% of the population in Uganda and 74% of the population in Kenya live below the corresponding national poverty lines. Less than half the population have access to safe drinking water, less than a third have access to sanitation units, and most of the region surpasses the World Food Organistaion's emergency threshold for malnutrition rates. Similarly, statistics on other health indicators and literacy rates are very low (see table 1.1).

1.3 Conceptual Framework

I present a simple contest model that specifies how resource variation could influence conflict and use this to motivate my empirical analysis.

I assume there are two states: $\{H,L\}$, that represent high resources or low resources. Each tribe's initial wealth, or endowment, depends on which state they are in: $\{E_{S_i=H}, E_{S_i=L}\}$ with $E_{S_i=H} > E_{S_i=L}$. When a tribe is in a state with greater forage availability, or more water, the condition and quantity of their livestock will be higher. However, the rewards to raiding depend not on the state the initiating tribe is in, but the state of the target tribe: $\{R_{S_j=H}, R_{S_j=L}\}$ with $R_{S_j=H} > R_{S_j=L}$ and $E_H > R_H, E_L > R_L$[7], since it is the quality and quantity of their livestock that is important. In the situation that the initiating tribe is unsuccessful during a raid, they are assumed to obtain a payoff that is normalized to zero, but regardless of the outcome of a raid, the initiating tribe faces a fixed cost of raiding: d. This cost can be interpreted as the expected risk of death to tribesmen incurred through raiding.

I assume that the probability a tribe is successful during a raid is a function of both the initiating tribe's resources and the target tribe's resources: $f(S_i,S_j)$ with $f(H,L) > f(H,H) > f(L,L) >$

[7] I make rewards strictly lower than endowments, to reflect the notion that by carrying out a raid, the initator is hoping to appropriate some of their target's endowment.

$f(L,H)$. When either tribe is in the high state, the health and strength of their warriors is likely to be higher as a result of an increased quality and quantity of livestock.

I assume utility is concave in the rewards to raiding and the endowment, but linear in the cost of raiding.[8] Thus, each tribe's decision on whether or not to raid depends on whether their expected gains exceed their costs. The conditions for raiding to occur in each of the four possible state combinations are:

$$f(H,H)[U(R_H+E_H)-U(E_H)]-d \geq 0$$

$$f(H,L)[U(R_L+E_H)-U(E_H)]-d \geq 0$$

$$f(L,H)[U(R_H+E_L)-U(E_L)]-d \geq 0$$

$$f(L,L)[U(R_L+E_L)-U(E_L)]-d \geq 0$$

This demonstrates that asymmetric increases to resources have an ambiguous affect on the decision to raid. For example, consider starting in the situation where both tribes are in the low resource state, if one tribe moves to the high resource state they will have a greater probability of success, but the marginal utility from a successful raid is lower as $[U(R_L+E_L)-U(E_L)] > [U(R_L+E_H)-U(E_H)]$, since utility is concave (see Figure 1-3). At the same time, the other tribe has more to gain from a successful raid, but a lower probability of success. Similarly, as tribes experience asymmetric decreases to resources, the most affected tribe will have more to gain from a successful raid, but a lower probability of success (see Figure 1-4).

Therefore, the empirical analysis will assess whether resource variation has a greater impact on the rewards to raiding vis-á-vis its impact on the probability of success, since I can attempt to directly estimate the impact variation in a tribe's own resources has on its probability of commiting a raid controlling for the resources of the other tribes. If there is a positive relationship between a tribe's own resources and their decision to raid, this would suggest that the impact on the probability of success outweighs the impact on the marginal rewards to raiding. However, a negative relationship between a tribe's own resources and their decision to raid, this would suggest that the

[8]Since the cost of raiding does not depend on the outcome of raiding it could also be interpreted as a direct measure of disutility, and this relaxes the interpretation of utility being linear in costs.

impact on the rewards to raiding outweighs the impact on the probability of success. Similarly, I can investigate the influence a potential target tribe's resources have on the initiating tribe's decision to raid.

The conceptual framework has so far abstracted from any direct impact that weather variation may have on ease through which tribes can carry out livestock raids. However, as was discussed earlier, it is plausible that weather conditions may directly influence the probability that tribes can carry out raids. For example, Adano and Witsenburg note that, "During the rainy seasons animals are in good condition and strong to withstand long distance trek, manpower demand is low, enhanced chance of rain to wash away tracks and rich vegetation cover, each or all in combination, enable raiding and increase the prospects of successful raiding" [83]. If this explanation fits the technology of livestock raiding across the Karamoja, increases in precipitation or forage for both the target and the initiator should increase the probability that the initiating tribe can successfully carry out a raid. In effect this justifies the assumption that $f(H,H) > f(L,L)$, particularly when the high resource state coincides with greater vegetation coverage and more surface water. To evaluate whether the model predicts raiding to be more or less likely when both parties move from the low resource to the high resource state, we should consider if:

$$f(H,H)[U(R_H+E_H)-U(E_H)] > f(L,L)[U(R_L+E_L)-U(E_L)]$$

Given the concavity of the utility function, it is likely that $U(R_H+E_H)-U(E_H) < U(R_L+E_L)-U(E_L)$, which suggests that the impact of such correlated changes to resources is ambiguous (see Figure 1-5).

1.4 Data and Empirical Methodology

1.4.1 Data

The conflict data comes from CEWARN (Conflict Early Warning and Response Mechanism), an initiative that was set up by the Intergovernmental Authority on Development (IGAD) in 2003 to monitor, prevent escalation or mitigate the worst effects of violent conflicts. CEWARN collects detailed accounts of all episodes of pastoral conflict and crime in the Karamoja Cluster by using field monitors to record reports of all these incidents. [9] These incident reports are coded by the level at which the information was obtained, and over 90% of the reports have either the field monitor as a direct observer, or the informant to the field monitor as a direct observer. The remainder are compiled based on police, newspaper, or radio reports.

The incident reports record the type of crime (livestock raid or theft, banditry, abduction, murder or rape), the date each crime occurs, the number of people involved, the outcomes to human life and property (such as the number of livestock taken), the tribes involved (who was the initiator and who was the target), and the location of the crime (up to the village level). This study focuses on the livestock thefts and raids for two reasons. First, livestock raids are the most salient form of conflict in the region and second, they are an appropriation activity where the rewards to raiding can plausibly be expected to vary with resource and water availability. Descriptive statistics on livestock raids and pastoral indicators are covered in Table 1.2.

The data on precipitation comes from FEWSNET - Famine Early Warning Systems Network [102], which provides gridded daily precipitation estimates for the Africa region (20W-55E, 40S-40N) on a 0.1 degree resolution. These precipitation estimates are based on four sources: daily GTS rain gauge data, AM SU microwave satellite precipitation 6-hourly estimates, SSM/I satellite precipitation 6-hourly estimates and GPI cloud-top infra-red temperature precipitation half-hourly estimates.

The forage data comes from a joint project between USAID and Texas A&M University that developed an early warning livestock system that reports on the monthly amount of forage available for livestock [93]. The data is gridded and available at a 4km x 4km resolution in kg/hectare. The forage data is estimated using satellite NDVI data as an input to a simulation model called PHYGROW that takes into account soil types and the demands of forage for different types of livestock, and the output of the model is then calibrated to data from around 430 monitoring sites.

I use three levels of spatial resolution to carry out my analysis. I first consider the aggre-

[9] Field monitors are CEWARN employees and must be able to speak the local dialects in the region they are deployed. In addition, they must be literate and are not natives of the region.

gate relationship between forage and precipitation across the Karamoja region as a whole. I begin by summing the daily precipitation recorded for each grid cell into a monthly total to match the frequency at which forage is available. Then for each of the forage and precipitation measures I compute a standardized measure for each monthly grid cell data point by using the long term (2000-2011) mean and standard deviation of each respective grid cell. This allows me to interpret these variables as location-specific deviations from long term or "natural" levels, which is an approach adopted by most other papers in the related literature to avoid unobservable confounding factors that may be location specific. In addition, a new weather-index insurance scheme in a nearby area, has adopted a payment schedule that relies on using such standardized measures of NDVI, a key determinant of the forage measure, to decide what payment should be made to pastoralists, demonstrating that there is a robust relationship between NDVI deviations and livestock mortality. [10] To obtain a monthly measure of forage and precipitation for the region as a whole, I simply take the unweighted mean level of these standardized grid cell observations for the Karamoja region. [11] As a complementary measure to assist my analysis, I calculate the proportion of monthly grid cell observations that recorded no precipitation. I refer to this measure as a drought index, as it is scaled between 0-1, and I use it to capture any direct and potentially non-linear impacts that the absence of rainfall may have on livestock raiding.

As a second level of spatial resolution, I consider the forage, precipitation and drought of both initiating and target tribes. To do this I need to make an assumption about the location of tribes to be able to attribute these resource and climate measures to each tribe. My method is to obtain detailed administrative maps of the region from the International Livestock Research Institute and combine these maps with multiple anthropological accounts on each tribe's traditional grazing area to match each tribe to different geographic areas. Most administrative geographic units take the name of a main tribal group, for example, Dodoth County is in the northern part of the Ugandan Karamoja and is where most anthropological accounts suggest the Dodoth tribe are located. Similarly, the

[10] See the International Livestock Research Institute's website: http://livestockinsurance.wordpress.com/ for more information.

[11] This part of the data preparation was done using ArcGIS software. I overlaid the co-ordinates of the centre of each grid cell observation on an adminstrative map of the region downloaded from http://web.mit.edu/geoweb/ (see Figure 1-1) to identify which grid cells to include.

Rift Valley Province of Kenya is divided into the districts of North, Central and South Turkana, and this is how I match the different Turkana tribes to geographic areas. While this methodology does rely on the assumption that geographic units can be meaningfully attributed to different tribes, there is also additional evidence to suggest this is reasonable: these administrative units originate from boundaries laid out by the British in 1911, to assign permanent territorial rights to different tribes, to aid the colonialist's control of order in the area [4], [83], [92]. The mapping of different tribes to particular geographic locations that I use is shown in Figure 2-2. Since both the forage and rainfall data is in gridded format, while the tribes traditional grazing areas are irregular shaped polygons, I use arcGIS software to map the gridded data into measures that are representative of each tribe by averaging across datapoints spatially.

The third level of spatial resolution that I consider is the location of livestock raids. The CE-WARN data includes detailed information on where raids take place and in some cases information up to the village level of spatial resolution is available. In order to obtain a consistent geographic unit of measurement, while trying to maintain a high level of spatial disaggregation, I have identified raids up to the sublocation level of detail in Kenya (74), the subcounty in Uganda (58), and by the area of reporting of field monitors in Ethiopia (3). A map of these geographic units for Kenya and Uganda is shown in Figure 1-6, and to see which geographic units I use for Ethiopia you can refer to the boundaries shown in Figure 2-2 as these also depict the areas covered by the field monitors. I present this third level of spatial analysis to complement the tribe level analysis, which may have limitations due to the possible concern that the forage and precipitations fluctuations cannot be precisely attributed to specific tribes. Thus, my approach is to present results both at the level of conflict interactions between tribes and at the most detailed level of location of conflict, to first look for a tribe-relevant climate effect on the direction of conflict, as well as considering location-relevant climate effect on the incidence of conflict, in case the first channel cannot be determined.

1.4.2 Empirical Methodology

Regionwide Analysis

To examine the incidence of conflict across the region as whole in relation to the average level of forage and precipitation. I estimate the following model:

$$log(conflict_t) = \alpha + \beta_1 forage_t + \beta_2 precipitation_t + \beta_3 drought_t + \gamma t + \Sigma_M \delta_M I[month_t = M] + \varepsilon_t$$

where $conflict_t$ is a measure of the total number of livestock raids, deaths due to livestock raiding, or livestock stolen during a month, $forage_t$ is a standardized monthly measure of forage, $precipitation_t$ is a standardized monthly measure of total precipitation, $drought_t$ is an index between 0 to 1 that captures the proportion of the grid cell observations across the region that record zero rainfall, γt controls for a regional time trend, δ_M controls for month of year fixed effects, and Newey-West standard errors that allow for serial correlation over 4 months are estimated.

To address potential concerns of serial correlation in the dependent variable, I also estimate the model in first differences with the resource measures $forage_t$ and $precipitation_t$:[12]

$$\Delta log(conflict_t) = \alpha + \beta_1 \Delta forage_t + \beta_2 \Delta precipitation_t + + \gamma t + \Sigma_M \delta_M I[month_t = M] + \varepsilon_t$$

Between Tribe Analysis

To examine the direction of conflict between tribes based on both the initiator's and the target's level of forage and precipitation, I construct a directed dyadic monthly panel. I consider all contiguous tribe pairs, as well as pairs that have ever violently interacted, even if they are not located next to each other. This panel is directed in the sense that a raid initiated by the Dodoth tribe on the Bokora tribe is classified separately to raid by the Bokora tribe to the Dodoth tribe. I estimate versions of

[12] I do not include $\Delta drought_t$ since the coefficient on such a variable would be difficult to interpret, given that $drought_t$ is an index measure.

the following model, where subscript i denotes the initiating tribe and subscript j denotes the target tribe:

$$conflict_{ijt} = \alpha + \rho conflict_{ijt-1} + \Sigma_{s=0,1}\beta_{1,s}^{init} forage_{it-s} + \Sigma_{s=0,1}\beta_{1,s}^{tgt} forage_{jt-s}$$

$$+\Sigma_{s=0,1}\beta_{2,s}^{init} precipitation_{it-s} + \Sigma_{s=0,1}\beta_{2,s}^{tgt} precipitation_{jt-s} + \Sigma_{s=0,1}\beta_{3,s}^{init} drought_{it-s}$$

$$+\Sigma_{s=0,1}\beta_{3,s}^{tgt} drought_{jt-s} + \gamma t + \Sigma_M \delta_M I[month_t = M] + \alpha_{ij} + \varepsilon_{ijt}$$

For the dependent variable I use both an indicator variable, $I[raid_{ijt} > 0]$, for any raiding, as well as logarithmic measures for the number of deaths and amount of livestock stolen. I estimate the model using a lag of the dependent variable as a covariate to directly address autocorrelation in conflict itself. I include forage, precipitation and drought measures for both the target and the initiator to identify whether resource and weather variations have asymmetric impacts dependent on whether it is the target or the initiator who encounters them, and I allow for persistence in such impacts through including the lags of these covariates. The inclusion of the lagged dependent variable makes this a dynamic panel regression specification and I adopt the generalized method of moments estimation technique proposed by Blundell and Bond (1998) [16]. Blundell and Bond (1998) show that the lagged-level instruments in the traditional Arellano-Bond estimator for linear dynamic panel-data estimation can become weak if the autoregressive process is too persistent, so they developed an alternative system estimator [6] [16].[13] In addition, given the potential for unobserved factors to influence the conflict relationship between pairs of tribes in either direction, I cluster the standard errors by undirected dyads in the specifications where $conflict_{ijt-1}$ is omitted and I cluster the standard errors by directed dyads in the specifications where $conflict_{ijt-1}$ is included. I include directed dyad fixed effects to address systematic conflict trends between tribes, and include month fixed effects and a linear time trend, to address regionwide variation in

[13]Building on the work of Arellano and Bover (1995), Blundell and Bond (1998) suggest using moment conditions in which lagged differences are used as instruments for the level equation in addition to the moment conditions of lagged levels as instruments for the differenced equation, and this estimator is now implementable using the xtdpd command in stata [7] [16]. The stata manual provides a useful summary of the required assumptions for valid estimation, one of which is that the the initial condition $E[\alpha_{ij}\Delta conflict_{ij2}] = 0$ holds for all ij dyads. In effect this means that there should be no correlation between the directed dyad fixed effects and the initial difference in conflict for a dyad.

conflict.[14]

Raid Location Analysis

For the third level of spatial analysis, where I estimate both the spatial and serial impacts of resource and weather fluctuations and I allow for spatial spillovers in conflict in neighboring locations, I construct a panel of geographic unit by month observations. I have identified raids up to the sublocation level of detail in Kenya (74), the subcounty in Uganda (58), and by the area of reporting of field monitors in Ethiopia (3), but for ease of notation I will refer to this data as a sublocation by month panel. In spatial statistical analysis the structure of spatial autocorrelation is commonly summarized using a spatial weighting matrix, W, where the spatial lag of a given variable, such as $forage_{it}$, is obtained by pre-multiplying the vector of observations across all sublocations at time t by the spatial weighting matrix, for example: $W forage_t$. I use an inverse distance matrix that can be created from new stata routines that prepare spatial data [29]. The co-ordinates of the centroid of each sublocation are used to calculate the distance between sublocations and then W is created with the weights inversely related to the distance between the sublocations. I truncate the weighting matrix such that sublocations that are greater than 50 km apart have weights set to zero and I minmax normalize the matrix so that each element is divided by the minimum of the largest row or column sum of the matrix.[15] Using this spatial framework I estimate versions of the following model, where subscript i denotes the sublocation where a raid occurs:

[14] I have also estimated these regressions with month by year fixed effects to even more flexibly control for any regionwide variation in conflict, and I find that my results are robust to this additional control.

[15] This maintains symmetry in the matrix which would not occur by normalizing by the row sum. However, it makes interpreting the coefficients from the regressions more complicated. Sublocations that are smaller will mechnically obtain more variation in their term of $(W) forage_t$, since they will have more non-zero weights in their corresponding row of W. The coefficient estimates for $\beta^w_{1,s}, \beta^w_{2,s}, \beta^w_{3,s}$, $s = 0, 1$, should be interpreted as the benchmark of the marginal impact on conflict for a unit change in forage or precipitation in all sublocations within a 50km radius of the sublocation with the most closely located neighbours. For this sublocation the row sum of weights is one. For other sublocations the row sum of weights will be less than one, reflecting the fact that the neighbouring sublocations are geographically further away, and thus, the spatial matrix imposes that spatial variation over greater distances has less influence. I have experimented with using row sum normalization instead, but I do not find that my results are significantly affected by the choice of normalization.

$$conflict_{it} = \alpha + \rho conflict_{it-1} + \lambda W.conflict_t + \Sigma_{s=0,1}\beta_{1,s}^{own} forage_{it-s} + \Sigma_{s=0,1}\beta_{1,s}^{w} W.forage_{t-s}$$

$$+\Sigma_{s=0,1}\beta_{2,s}^{own} precipitation_{it-s} + \Sigma_{s=0,1}\beta_{2,s}^{w} W.precipitation_{t-s} + \Sigma_{s=0,1}\beta_{3}^{own} drought_{it-s}$$

$$+\Sigma_{s=0,1}\beta_{3,s}^{w} W.drought_{t-s} + \gamma t + \Sigma_M \delta_M I[month_t = M] + \alpha_i + \varepsilon_{it}$$

For the dependent variable I again use both an indicator variable, $I[raid_{it} > 0]$, for any raiding, as well as logarithmic measures for the number of deaths and amount of livestock stolen. In all the specifications at this level of analysis I include sublocation fixed effects, α_i, month of year fixed effects, δ_M, and a linear time trend.[16] However, I build up the specification shown above in several steps. First, I include only the covariates $forage_{it}$, $precipitation_{it}$, $drought_{it}$, but specify the structure of the error to be spatial in nature:

$$\varepsilon_{it} = \tau W.\varepsilon_t + \mu_{it}$$

Second, I include spatial lags of the forage and precipitation measures as well as sublocation-specific measures, but consider only contemporaneous effects for both sets of measures, and I continue to use a spatial error model. Third, I add lagged effects for both direct and spatial measures of forage and precipitation. These three specifications are static in that they do not include a lag of the dependent variable and can be considered spatial Durbin models (Anselin, 1988 [5]), which are estimable using GMM.

Next I introduce spatial and serial lags of the dependent variable. I start by including only $conflict_{it-1}$ and estimate the model using the Blundell and Bond (1998) estimator with standard errors clustered by sublocation. Then I include $W.conflict_t$ and estimate using both a spatial autoregressive model and a spatial durbin model, where I also include serial lags of the forage and precipitation measures. For both these latter specifications, standard errors are clustered by sublo-

[16]Unfortunately, I was not able to check the robustness of these regressions by adding with month by year fixed effects instead of month of year fixed effects due to computational constraints.

cation. Spatial dynamic models encounter not only endogeneity concerns through the inclusion of the lagged dependent variable, but also need special consideration to both the direct effects of the covariates on the dependent variable and the indirect effects of the covariates on the conflict in nearby sublocations, that in turn affects conflict in the primary sublocation. Elhorst (2010) and Lee and Yu (2010) have proposed quasi-maximum likelihood techniques to estimate such spatial dynamic models and this approach is now easy to implement using the stata xsmle command developed by Belotti, Hughes and Mortari (2013) [33] [52] [9].

1.5 Results

1.5.1 Regionwide Analysis

Table 1.4 examines the aggregate impact of forage and precipitation variation across the Karamoja Region using conflict and weather data that is collapsed into a single time series. Looking at column (1), I find that a standard deviation increase in the average level of forage across the region has no impact on the total number of raids, but a standard deviation increase in the average level of precipitation leads to about a 22% increase in the number of raids and increases in the proportion of land with no rainfall, also leads to increases in the number of raids. The coefficient estimates suggest that an increase in the proportion of land with no rainfall of 10% would lead to a 4% increase in the number of raids. This non-linear impact of rainfall can be observed by looking at Figure 1-8. This figure shows the total number of raids observed for each decile of average precipitation for the region, and demonstrates that there is both a large number of raids in the lowest deciles as well as in the highest deciles of the precipitation distribution. In contrast, at the aggregate level there appears to be no systematic relationship between forage and raiding.

However, columns (2) and (3) suggest that decreases in the average level of forage across the region is accompanied by increases to the number of deaths and the amount of livestock stolen during raids. The regression results suggest that a standard deviation decrease in the average level of forage coincides with a 23% increase in the number of deaths and a 44% increase in the number of livestock. Figures 1-9 and 1-10 show the number of deaths and livestock stolen for each decile in the average forage for the region. Figure 1-10 reinforces the results of a negative correlation between livestock stolen and forage, while Figure 1-9 shows some nonlinearities in the relationship between deaths and forage, questioning the robustness of the results from the linear regression analysis.

The analysis on the relationship between precipitation and the number of deaths and the amount of livestock stolen during raids, also suggests some nonlinearities. While the regression results shown in Table 1.4 find only a significant positive correlation between precipitation and these measures of conflict, Figures 1-9 and 1-10 show nonlinearities as I see both a greater number of deaths and more livestock being stolen during low precipitation deciles as well as high precipitation deciles.

As a robustness check to address concerns about serial correlation in residuals, I also present regression results in first differences in Table 1.5. Here I find that increases in precipitation are associated with increases in both the number of raids and the amount of livestock stolen, but no relationship between forage and conflict. As a further robustness check on the results shown in Table 1.4, Tables 1.12 to 1.14 in the appendix, repeat the level regressions, with each measure of precipitation or forage included individually as a regressor. The coefficient estimates are approximately stable, whether or not each measure of weather variation is controlled for separately. This is not that unusual given that there is low contemporaneous correlation between these measures (see Table 1.3 and Figure 1-7).

These results on the aggregate impact of forage and precipitation variation on conflict across the Karamoja Region show a non-linear relationship between pastoral raiding and precipitation, with both more raids occuring during dry periods as well as during wet periods. This contrasts the earlier qualititative and case study research by Adano et al. (2009), which found that within Kenya raiding did not occur during dry periods [83], but is in line with the results reported by Stites et al. (2010) [92], which found that more conflict tended to occur during the dry periods in Uganda when tribes were forced to graze their animals in closer proximity and share access to water holes. The results on the relation between forage and conflict are not conclusive for the total number of raids or deaths measures, but there does appear to be a robust negative relationship between the amount of livestock stolen and forage availability, suggesting that in times of plenty the risk of losing livestock through pastoral raids decreases. In the following section I will attempt to unpack these results by examining how pastoral raiding is directed based on tribe level variation in forage and precipitation, to assess whether resource scarcity is at the root of pastoral raiding, and also whether raids occur in localities with more surface water following rainfall.

1.5.2 Between Tribe Analysis

Column (1) of Table 1.6 shows that there appears to be a negative relationship between the level of forage of an initiating tribe and the probability that they initiate at least one raid. One interpretation of this result is that when tribes have healthy livestock and larger herd sizes, reflecting their own high level of forage, the marginal gains to raiding are sufficiently low so that these tribes are unwilling to carry out raids, even though they may have some advantage in carrying out such raids. This result, however, is not robust to the inclusion of measures of the target tribe's forage or precipitation, or lagged measures for either the target's or initiator's forage or precipitation. Correlation between forage or precipitation measures for both the initiating and target tribe is high: 0.913 for forage, 0.824 for precipitation and 0.836 for drought (see Table 1.3). This makes it difficult to identify the impact of each variable separately, as such a high degree of collinearity makes the point estimates imprecise. The coefficient estimates on the target's forage measures are also negative, which could suggest that the probability of being able to successfully execute a raid is important as well. However, given that neither coefficient can be precisely estimated when the regression controls for both the initiator's and the target's resources, it is not possible to conclude whether the decrease in the likelihood that the initiator attempts a raid is due to a decrease in the marginal returns as the initiating tribe is resource rich or a decrease in the probability they will be successful, when their target is also resource rich and more able to resist a raid.

The results on precipitation measure face similar problems of collinearity, and there does not appear to be a clear relationship between how precipitation fluctuations experienced by either the target or the initiator influence the direction of raiding. The results on the drought measure are more promising and suggest that when more of the initiator's grazing area lacks rainfall, the initiator is more likely to attempt a raid. This result is robust to controlling for the measure of drought for the target, which does not appear to directly influence the direction of raiding. Together, these results for the forage and drought measures suggest that desperation is a greater motivator of pastoral raiding, than strategic predation, with raids being initiated when the marginal returns to raiding are greatest, rather than when the probability of success is highest.[17]

There is significant serial correlation in the direction of raiding, as demonstrated by the inclusion of the lagged dependent variable. If the initiator raided the target in the previous month, they are about 11% more likely to raid them again in the current month. This suggests that there are underlying reasons for raiding that are neither captured by weather fluctuations or by time constant tensions, such as long term animosity between specific pairs, or proximity to each other, which should be captured by the directed dyad fixed effects. Grievances and retribution could potentially explain these trends, since such motives could plausibly vary across time and involve a high level of autocorrelation. This autocorrelation in conflict is found with the other conflict measures: deaths due to raids and livestock stolen, and these results can be seen in Table 1.7 and Table 1.8.[18]

Table 1.7 examines the relationship between forage and precipitation with the death rate due to raids. These results echo the results found in Table 1.6 as there does not appear to be a pronounced relationship between either the initiator's forage or precipitation measures, or the target's measures, and the deaths that occur due to raiding. The results on the drought measure are stronger and suggest that when more of the initiator's grazing area lacks rainfall, the total number of deaths due to raiding increases. This result is robust to controlling for the measure of drought for the target, which appears to have a weakly negative impact on the total number of deaths. Thus, dry weather for the initiator appears to not only encourage more raiding, but also leads to a higher death rate, while dry weather for the target may reduce the number of deaths they incur due to raiding.

[17] The results shown in Tables 1.6 to 1.8 remain unchanged when monthly fixed effects are included instead of month of year fixed effects, which enable more flexible treatment of any regionwide trends in conflict.

[18] Tables 1.15 to 1.17 estimate the dynamic panel specifications using OLS as well as the GMM procedure proposed by Blundell and Bond (1998) [16]. A comparison of the coefficient estimates on the lagged dependent variable in the OLS results, shown in columns (1)-(3), to the GMM results, shown in columns (4)-(6), demonstrates the positive bias in the OLS estimates, which do not take into account the mechanical correlation between the unobserved panel-level effects and this covariate.

Table 1.8 examines the relationship between forage and precipitation with the total number of livestock stolen. These results are in line with the earlier results as they show that dry weather for the initiator leads to a greater volume of livestock being stolen, while dry weather for the target appears to weakly reduce this outcome. However, unlike the earlier analysis, there appears to be a more robust negative relationship between the initiator's forage and the amount of livestock they obtain during raids, lending further support to the explanation that during times of resource scarcity, tribes raid more frequently.

Figures 1-11 to 1-16 complement this regression analysis, and show a negative correlation between the target's forage and the frequency at which they are raided and the amount of livestock they lose through raids. The figures examining the relationship between the initiator's forage and raiding, however, show some degree of nonlinearity with both more raids and more livestock being taken during low and high deciles of the initiator's forage, which is not captured in the linear specifications adopted in the regression analysis. The figures examining precipitation show no systematic relationship between conflict and either the initiator's or the target's rainfall exposure.

To summarize these results, I find that:

- there is significant autocorrelation in the direction of raiding, suggesting that grievances and retribution play an important motivating role for conflict, beyond weather fluctuations or traditional rivalries,

- dry weather increases the likelihood that tribes initiate raids and increases the number of livestock stolen, but, where feasible, tribes appear to raid targets who were less exposed to the decline in rainfall,

- increases in rainfall to either the target or the initiator do not lead to increases in the level of raiding or impact the number of livestock stolen,

- while increases to forage reduce the demand to raid by the initiating tribe and the targets' vulnerability to raids, the visual analysis from the figures show that there may be some degree of nonlinearity in this relationship,

- collinearity in the precipitation and forage measures makes it difficult to identify the impact of each variable separately in the regression analysis.

1.5.3 Raid Location Analysis

Tables 1.9 to 1.11 present the third level of spatial analysis where I use the sublocation by month panel to consider the relationship between conflict and location-specific weather using more detailed information about where raids take place. Tables 1.9 and 1.11 show a negative relationship between the availability of forage and the location of raids and the amount of livestock stolen, although the coefficient estimates are only significant for some of the livestock specifications and relate to about a 2.5-6.5% increase in the number of livestock stolen following a standard deviation decrease in the average level of forage in the sublocation. Figures 1-17 and 1-19, however, show a less clear relationship, with both a large number of raids and livestock losses occuring when sublocations record low and high forage levels. The results in Tables 1.9 to 1.11 suggest no relationship between the availability of forage in the surrounding sublocations and conflict in the immediate sublocation. For the regression results at the sublocation level to be in line with the results analysed at the tribe dyad level, this implies that tribes must raid locally, as the tribe-dyad analysis showed forage-scarce tribes were more likely to initiate raids.

Tables 1.9 and 1.11 show a positive relationship between precipitation in the previous month and the incidence of raids and the amount of livestock stolen, with a standard deviation increase in precipitation leading to about a 2% increase in the probability that the sublocation will be raided and about a 8% increase in the number of livestock stolen, in the following month. These results are consistent with the explanations put forward by Adano et al. (2009), as they suggested that surface water enables tribes to more easily carry out raids [83], although it is somewhat surprising that precipitation in the surrounding sublocations does not appear to have any impact livestock raiding, as one would anticipate the livestock would be moved across sublocations after a raid. However, this finding is also in line with the explanation that raiding occurs at a very local level. Table 1.10 shows that the death rate significantly increases when wet weather is experienced both in the sublocation of the raid and in the surrounding sublocations: a standard deviation increase in precipitation in the sublocation of the raid increases the number of deaths by about 2% and a standard deviation increase in precipitation in the neighbouring sublocations increases the number of deaths by about 5%.

Interestingly, conflict is also more likely to occur in sublocations that lack rainfall. Table 1.11 shows that after a month with very little rainfall, sublocations are more vulnerable to livestock losses and Table 1.10 shows that during this month sublocations incur more deaths from livestock raids. These findings could be consistent with the explanations put forward by Stites et al. (2010) [92], that more conflict occurs during the dry periods when tribes are forced to graze their animals in closer proximity and share access to water holes. Thus, my analysis at the highest degree of spatial resolution, finds agreement with both the research carried out by Witsenburg, Adano and Dietz, and Akabwai, Stites and Fries - there is both a greater risk of pastoral raids occuring during months in which a sublocation experiences very little rainfall and following months in which there has been an abundance of rainfall. Figures 1-17 to 1-19 reinforce these findings and show a bimodal relationship between conflict and precipitation.

At the sublocation level there is also a high degree of serial autocorrelation, with raids being around 10% more likely to occur if they occurred in the previous month. However, there does not appear to be any spatial autocorrelation in conflict, indicating that pastoral raiding is less vulnerable to contagion and spatial spillover effects.

To summarize these results I find:

- there is significant serial autocorrelation in the incidence of raiding, but no spatial autocorrelation,
- both dry and wet weather increases the likelihood that a sublocation will be vulnerable to raids, livestock losses and the associated deaths due to this type of conflict. These impacts are contemporaneous with respect to the outcomes on deaths, while they occur with a month's lag with respect to livestock losses.
- the data available has not enabled me to find a strong relationship between forage and raiding at the sublocation level of analysis. There is some indication that sublocations with lower

levels of forage are more vulnerable to raids, but this result is weak.

1.6 Conclusions

Internal armed conflict is a prevalent issue in the modern world that has attracted a significant amount of academic attention. In particular, an expansive cross-disciplinary literature has emerged that examines the relationship between climatic changes and conflict. A recent review of the literature compiled the 50 most rigorous quantitative studies and found that for each standard deviation change in climate towards more extreme rainfall the frequency of interpersonal violence rises by 4% and the frequency of intergroup conflict rises by 12% [42]. This paper complements this literature by following similar methodological approaches to earlier studies and focuses on conflict in Sub-Saharan Africa, but uses a different source of conflict data that contains much more detailed information on the location of conflict and the groups involved in conflict, enabling a more micro-level analysis of conflict and weather variation.

The data I use contains detailed information on conflict between tribes in the Karamoja region of East Africa. This conflict arises during livestock raids where tribes in the region attack each other with the intention of obtaining livestock. Since pastoralism is the dominant livelihood in the region, this type of conflict can be considered a type of resource appropriation, where the resources are the animals stolen during raids, and these resources (livestock), can be expected to fluctuate in quality and quantity with forage and precipitation variation in the region.

However, even within this context of conflict between tribes, forage and precipitation variation could have an ambiguous effect. On the one hand, positive resource fluctuations could increase a tribe's probability of completing a successful raid, but on the other hand, positive resource fluctuations may lower a tribe's marginal utility from a successful raid. Similarly, the resources of the target could have an ambiguous impact on the initiating tribe's decision to raid: a target with greater resources may be more attractive as the potential rewards to raiding them will be higher, but the probability of successfully raiding them may be lower. Furthermore, climatic conditions may directly influence the ease at which livestock raids can be carried out. For example, vegetation coverage can help raiders to hide before ambushing their target, and surface water from rainfall can making tracking animals easier (Adano and Witsenburg 2005 [100]).

My results suggest that across the region there is a bimodal relationship between conflict and precipitation, with more pastoral raids occurring when there is both very little and a lot of rainfall across the Karamoja region. A standard deviation increase in the average level of precipitation leads to an increase in raids per month of about 22%, and an increase in the proportion of land with no rainfall of 0.1 leads to a 4% increase in raids per month. A standard deviation decrease in average level of forage has no impact on the number of raids per month, but increases the number of deaths by 23% and the number of livestock stolen by 44%. Thus, at the aggregate level there is evidence of resource-scarcity leading to more conflict and wet weather improving the conditions for raiding.

When tribe specific and sublocation specific variation in resources is examined, the relationship between forage and raiding is less clear. There is some indication that forage-scarcity motivates tribes to carry out raids and forage-scarce sublocations appear to be more vulnerable to raids and livestock losses, but these results are not robust to all specifications. Regardless though, my results are not in agreement with earlier empirical work using the same data, that found that greater vegetation coverage led to more raids [65].

There is also a bimodal relationship between conflict and precipitation at the sublocation level, with a higher likelihood of raids occurring in the month following both very little and a lot of rainfall. The death rate is higher in months with either very little or a lot of rainfall as well. At the tribe-dyad level, I find that tribes that have recently experienced very dry weather are more likely to initiate raids, steal more livestock, and be responsible for a larger number of pastoral deaths, but I do not find that extreme positive deviations of precipitation affect these outcomes.

Together these results suggest that conflict in the Karamoja region is correlated with extreme precipitation fluctuations in either a positive or negative direction. Forage-scarcity may also be a motivator for tribes to initiate raids, but this relationship is weak and would benefit from a longer time series of data or direct data on herd sizes and health, to help to conclusively identify any type of systematic relationship. Thus, these results are consistent with raids occurring when tribes encounter the greatest marginal gains to raiding because they are resource-scarce, due to both negative forage and precipitation deviations, but they are also consistent with several other explanations. First, that surface water may increase the ease at which tribes can successully carry out raids, encouraging more raiding, and second, that conflict is more likely to erupt when tribes are forced to locate in closer proximity because access to forage and water is more scarce. To distinguish between these channels, more precise data on the grazing locations of different tribes, across time and space, would be very helpful. Furthermore, there is a significant degree of serial autocorrelation in conflict, suggesting that there are other important motives for pastoral raiding that are not correlated with weather variation, but do vary across time.

1.6.1 Tables

Table 1.1: Selected Human Development Indicators

	Uganda National	Uganda Karamoja	Kenya National	Kenya Karamoja
Life Expectancy (1)	50.4 yrs	47.7 yrs	52.0 yrs	46.9 yrs
Population living below poverty line (2)	31%	82%	58%	74%
Maternal mortality rate (per 100,000 live births) (3)	435	750	414	.
Infant mortality rate (per 1,000 live births) (4)	76	105	55	.
Under 5 mortality rate (per 1,000 live births) (4)	134	174	84	.
Global Acute Malnutrition (GAM) rate (5)	6%	11%	5%	15%
Access to sanitation units (4)	62%	9%	31%	32%
Access to safe water (4)	63%	40%	59%	52%
Literacy rate (3)	67%	11%	73%	.
Population Projection (6)		1,062,300		502,000

Sources: 1.UNDP 2007; 2. World Bank 2006; 3. UDHS 2006; 4. UNICEF/WHO 2008; 5. MoH/WFP April 2009; 6. UBOS 2009, GoK 2008.

Table 1.2: Selected Conflict, Pastoral and Resource Indicators

Population (1)	1,564,300
Total Cattle (1)	1,707,345
Other livestock (1)	4,770,786
Cattle per Household (1)	13.3
Average Household Size (1)	6.2
Livestock Raids (per month per tribe) (2)	1.39 (2.40)
Deaths (per month per tribe) (2)	1.91 (10.1)
Livestock stolen (per month per tribe) (2)	235 (844)
Normalized Forage per tribe per month (3)	-0.177 (0.972)
Normalized Precipitation per tribe per month (4)	0.029 (0.867)
Drought measure per tribe per month (4)	0.155 (0.323)

Sources: 1. UBOS 2009, GoK 2008, 2. CEWARN 2004-2009, 3. LEWS forage data [93], 4. FEWS precipitation data [102] ; Standard deviation in parenthesis.

Table 1.3: Correlation between Forage and Precipitation Measures

Regionwide Time Series

	forage	precipitation	drought
forage	1	.	.
precipitation	-0.246	1	.
drought	0.153	-0.629	1

Tribe-Dyad Panel

	own forage	own precipitation	own drought	target's forage	target's precipitation	target's drought
own forage	1	.	.	.	.	.
own precipitation	0.025	1	.	.	.	.
own drought	0.142	-0.251	1	.	.	.
target's forage	0.913	0.034	0.117	1	.	.
target's precipitation	0.034	0.824	-0.212	0.025	1	.
target's drought	0.118	-0.211	0.836	0.142	-0.251	1

Sublocation Panel

	forage	precipitation	drought	W.forage	W.precipitation	W.drought
forage	1	.	.	.	.	.
precipitation	-0.06	1	.	.	.	.
drought	0.038	-0.574	1	.	.	.
W.forage	0.509	-0.048	-0.012	1	.	.
W.precipitation	-0.046	0.53	-0.348	-0.096	1	.
W.drought	-0.005	-0.305	0.332	-0.132	-0.572	1

Regionwide Analysis

Table 1.4: Conflict across the Karamoja Region

Dep. Var.:	$log(Raids_t)$	$log(Deaths_t)$	$log(Livestock_t)$
forage	-0.0129	-0.2295	-0.4447
	[0.0477]	[0.1330]*	[0.1646]***
precipitation	0.2219	0.4476	0.6917
	[0.0854]**	[0.1917]**	[0.2030]***
drought	0.4023	0.5556	0.4427
	[0.1881]**	[0.4277]	[0.7950]
N	79	79	79
t-trend	yes	yes	yes
Month FE	yes	yes	yes
SE	NW	NW	NW
Mean of Dep Var	25.18	61.72	3366

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. NW SE indicates that Newey-West standard errors were computed that allow for heteroskedasticity and autocorrelation up to a degree of 4 lags.

Table 1.5: Conflict across the Karamoja Region

	$\Delta log(Raids_t)$	$\Delta log(Deaths_t)$	$\Delta log(Livestock_t)$
Δ forage	0.0009	-0.0010	0.0004
	[0.0008]	[0.0011]	[0.0019]
Δ precipitation	0.0042	0.0039	0.0114
	[0.0017]**	[0.0047]	[0.0041]***
N	78	78	78
t-trend	yes	yes	yes
Month FE	yes	yes	yes
SE	NW	NW	NW
Mean of Dep Var	25.18	61.72	3366.28

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. NW SE indicates that Newey-West standard errors were computed that allow for heteroskedasticity and autocorrelation up to a degree of 4 lags.

Tribe-dyad Analysis

Table 1.6: Raiding between Tribes in the Karamoja

Dep. Var.: $I(Raids_{ijt} > 0)$		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$I(Raids_{ijt-1} > 0)$				0.1163	0.1152	0.1148
				[0.0184]***	[0.0188]***	[0.0188]***
own forage	-0.0124	-0.0081	-0.0039	-0.0177	-0.0010	-0.0030
	[0.0044]***	[0.0061]	[0.0095]	[0.0098]*	[0.0192]	[0.0286]
own forage, t-1			-0.0082			-0.0028
			[0.0085]			[0.0348]
target's forage		-0.0045	-0.0088		-0.0189	-0.0202
		[0.0077]	[0.0120]		[0.0229]	[0.0353]
target's forage, t-1			0.0072			0.0032
			[0.0097]			[0.0393]
own precip	0.0006	0.0016	0.0002	0.0030	0.0021	0.0006
	[0.0033]	[0.0061]	[0.0064]	[0.0095]	[0.0204]	[0.0208]
own precip, t-1			0.0010			-0.0032
			[0.0058]			[0.0163]
target's precip		-0.0011	-0.0011		0.0005	-0.0022
		[0.0057]	[0.0055]		[0.0206]	[0.0210]
target's precip, t-1			0.0047			0.0174
			[0.0049]			[0.0142]
own drought	0.0181	0.0129	0.0002	0.0530	0.0657	0.0430
	[0.0113]	[0.0157]	[0.0166]	[0.0361]	[0.0469]	[0.0503]
own drought, t-1			0.0351			0.0709
			[0.0143]**			[0.0408]*
target's drought		0.0075	0.0115		-0.0079	-0.0169
		[0.0119]	[0.0127]		[0.0493]	[0.0475]
target's drought, t-1			-0.0154			-0.0095
			[0.0165]			[0.0459]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Table 1.7: Deaths due to Raids between Tribes in the Karamoja

Dep. Var.: $log(Deaths_{ijt})$		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$log(Deaths_{ijt-1})$				0.1315	0.1321	0.1306
				[0.0249]***	[0.0251]***	[0.0252]***
own forage	-0.0046	-0.0081	-0.0053	-0.0086	-0.0271	-0.0434
	[0.0057]	[0.0074]	[0.0128]	[0.0134]	[0.0235]	[0.0391]
own forage, t-1			-0.0077			0.0212
			[0.0110]			[0.0358]
target's forage		0.0037	0.0059		0.0179	0.0343
		[0.0065]	[0.0141]		[0.0256]	[0.0381]
target's forage, t-1			0.0034			-0.0194
			[0.0116]			[0.0347]
own precip	0.0034	-0.0019	-0.0029	0.0165	0.0032	0.0061
	[0.0061]	[0.0094]	[0.0095]	[0.0183]	[0.0230]	[0.0248]
own precip, t-1			-0.0062			-0.0099
			[0.0080]			[0.0303]
target's precip		0.0066	0.0085		0.0130	0.0127
		[0.0066]	[0.0065]		[0.0227]	[0.0247]
target's precip, t-1			0.0007			0.0028
			[0.0072]			[0.0296]
own drought	0.0443	0.0744	0.0647	0.2160	0.2995	0.2717
	[0.0153]***	[0.0293]**	[0.0283]**	[0.0525]***	[0.0759]***	[0.0746]***
own drought, t-1			0.0268			0.0843
			[0.0192]			[0.0845]
target's drought		-0.0392	-0.0334		-0.1207	-0.1339
		[0.0245]	[0.0214]		[0.0852]	[0.0771]*
target's drought, t-1			-0.0191			-0.0106
			[0.0199]			[0.0651]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Table 1.8: Livestock losses due to Raids between Tribes in the Karamoja

Dep. Var.: $log(Livestock_{ijt})$		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$log(Livestock_{ijt-1})$				0.1636	0.1620	0.1614
				[0.0241]***	[0.0243]***	[0.0246]***
own forage	-0.0596	-0.0552	-0.0503	-0.1214	-0.1003	-0.2164
	[0.0218]***	[0.0282]*	[0.0432]	[0.0452]***	[0.0991]	[0.1409]
own forage, t-1			-0.0108			0.1317
			[0.0438]			[0.1677]
target's forage		-0.0051	-0.0058		-0.0211	0.0424
		[0.0306]	[0.0435]		[0.1017]	[0.1636]
target's forage, t-1			0.0037			-0.0851
			[0.0388]			[0.1854]
own precip	0.0064	0.0119	0.0099	0.0045	0.0510	0.0517
	[0.0158]	[0.0262]	[0.0291]	[0.0414]	[0.0836]	[0.0857]
own precip, t-1			-0.0135			0.0280
			[0.0283]			[0.0793]
target's precip		-0.0053	-0.0077		-0.0464	-0.0501
		[0.0236]	[0.0230]		[0.0859]	[0.0814]
target's precip, t-1			0.0283			0.0161
			[0.0264]			[0.0870]
own drought	0.1372	0.1982	0.1734	0.5811	0.6937	0.6556
	[0.0739]*	[0.0875]**	[0.0856]**	[0.2468]**	[0.2835]**	[0.2987]**
own drought, t-1			0.0653			0.1717
			[0.0671]			[0.2221]
target's drought		-0.0816	-0.0720		-0.1526	-0.1427
		[0.0504]	[0.0553]		[0.2006]	[0.2050]
target's drought, t-1			-0.0314			-0.0856
			[0.0908]			[0.2302]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Sublocation Analysis

Table 1.9: Raiding among Sublocations in the Karamoja

Dep. Var.: $I(Raids_{it} > 0)$ MLE*	(1)	(2)	(3)	(4)	(5)	(6)
$I(Raids_{it-1} > 0)$				0.0875	0.1161	0.1149
				[0.0200]***	[0.0220]***	[0.0218]***
$W.I(Raids_{it} > 0)$					0.0158	0.0007
					[0.0287]	[0.0320]
own forage	-0.0040	-0.0047	-0.0084	-0.0090	-0.0044	-0.0098
	[0.0031]	[0.0036]	[0.0074]	[0.0109]	[0.0047]	[0.0082]
own forage, t-1			0.0023			0.0023
			[0.0074]			[0.0084]
W. forage		0.0071	0.0313	0.0160	0.0098	0.0216
		[0.0127]	[0.0306]	[0.0475]	[0.0199]	[0.0406]
W. forage, t-1			-0.0265			-0.0206
			[0.0308]			[0.0345]
own precip	0.0060	0.0054	-0.0002	0.0267	0.0053	-0.0003
	[0.0065]	[0.0070]	[0.0075]	[0.0175]	[0.0075]	[0.0070]
own precip, t-1			0.0200			0.0199
			[0.0075]***			[0.0075]***
W. precip		0.0091	0.0079	0.0401	0.0121	-0.0005
		[0.0253]	[0.0279]	[0.0616]	[0.0177]	[0.0209]
W. precip, t-1			-0.0336			-0.0259
			[0.0291]			[0.0249]
own drought	0.0032	0.0001	-0.0015	0.0155	-0.0006	-0.0010
	[0.0147]	[0.0151]	[0.0160]	[0.0339]	[0.0149]	[0.0142]
own drought, t-1			0.0122			0.152
			[0.0160]			[0.0140]
W. drought		0.0738	0.0826	0.2320	0.0751	0.0736
		[0.0643]	[0.0715]	[0.1418]	[0.0586]	[0.0724]
W. drought, t-1			-0.0655			-0.0602
			[0.0725]			[0.0602]
R2	0.00	0.00	0.01		0.10	0.00
N	9,000	9,000	8,625	8,875	8,875	8,500
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
Model	SEM	SEM	SEM	ArBo	SAR	SDM

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. SEM - Spatial Error Model; ArBo - Arellano and Bond Model (GMM); SAR - Spatial Autoregressive Model; and SDM - Spatial Durbin Model. * - All estimation, apart from the Arellano and Bond model, use maximum likelihood.

Table 1.10: Deaths due to raiding in Sublocations in the Karamoja

Dep. Var.: $log(Deaths_{it})$ MLE*	(1)	(2)	(3)	(4)	(5)	(6)
$log(Deaths_{it-1})$				0.0456	0.0555	0.0618
				[0.0313]	[0.0337]	[0.0362]*
$W.log(Deaths_{it})$					-0.0739	0.0716
					[0.0366]**	[0.0432]
own forage	0.0015	0.0010	0.0127	-0.0012	0.0018	0.0117
	[0.0037]	[0.0043]	[0.0088]	[0.0131]	[0.0052]	[0.0098]
own forage, t-1			-0.0133			-0.0123
			[0.0089]			[0.0093]
W. forage		0.0064	0.0392	-0.0157	0.0060	0.0132
		[0.0150]	[0.0357]	[0.0616]	[0.0248]	[0.0511]
W. forage, t-1			-0.0293			-0.0096
			[0.0360]			[0.0408]
own precip	0.0254	0.0196	0.0159	0.0526	0.0205	0.0157
	[0.0078]***	[0.0084]**	[0.0089]*	[0.0221]**	[0.0084]**	[0.0077]**
own precip, t-1			-0.0044			-0.0029
			[0.0090]			[0.0086]
W. precip		0.0516	0.0577	0.0512	0.0572	0.0405
		[0.0300]*	[0.0326]*	[0.0678]	[0.0262]**	[0.0381]
W. precip, t-1			-0.0331			-0.0167
			[0.0340]			[0.0360]
own drought	0.0389	0.0360	0.0248	0.1321	0.0354	0.0197
	[0.0177]**	[0.0183]*	[0.0191]	[0.0490]***	[0.0183]*	[0.0185]
own drought, t-1			0.0299			0.276
			[0.0192]			[0.0152]*
W. drought		0.0574	0.0404	-0.0881	0.0751	0.0170
		[0.0764]	[0.0838]	[0.1366]	[0.0838]	[0.1006]
W. drought, t-1			0.0061			0.0281
			[0.0848]			[0.0177]
R2	0.00	0.00	0.01		0.10	0.00
N	9,000	9,000	8,625	8,875	8,875	8,500
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
Model	SEM	SEM	SEM	ArBo	SAR	SDM

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. SEM - Spatial Error Model; ArBo - Arellano and Bond Model (GMM); SAR - Spatial Autoregressive Model; and SDM - Spatial Durbin Model. * - All estimation, apart from the Arellano and Bond model, use maximum likelihood.

Table 1.11: Livestock due to raiding in Sublocations in the Karamoja

Dep. Var.: $log(Livestock_{it})$ MLE*	(1)	(2)	(3)	(4)	(5)	(6)
$log(Livestock_{it-1})$				0.1008	0.1099	0.1123
				[0.0237]***	[0.0259]***	[0.0265]***
$W.log(Livestock_{it})$					0.0168	0.0262
					[0.0294]	[0.0305]
own forage	-0.0289	-0.0282	-0.0517	-0.0687	-0.0256	-0.0650
	[0.0137]**	[0.0157]*	[0.0325]	[0.0437]	[0.0163]	[0.0308]**
own forage, t-1			0.0217			0.0253
			[0.0327]			[0.0312]
W. forage		0.0044	0.0842	0.0106	0.0144	0.0863
		[0.0565]	[0.1366]	[0.2049]	[0.0737]	[0.1653]
W. forage, t-1			-0.0855			-0.0916
			[0.1376]			[0.1334]
own precip	0.0471	0.0406	0.0207	0.0818	0.0414	0.0124
	[0.0284]	[0.0306]	[0.0329]	[0.0771]	[0.0348]	[0.0327]
own precip, t-1			0.0759			0.0822
			[0.0331]**			[0.0345]**
W. precip		0.0802	0.0658	-0.1152	0.0787	0.0352
		[0.1128]	[0.1251]	[0.2635]	[0.0895]	[0.1025]
W. precip, t-1			-0.0639			-0.0649
			[0.1302]			[0.1511]
own drought	0.0702	0.0500	0.0147	0.1750	0.0512	0.0168
	[0.0645]	[0.0661]	[0.0703]	[0.1732]	[0.0682]	[0.0653]
own drought, t-1			0.1322			0.1398
			[0.0704]*			[0.0634]**
W. drought		0.4254	0.4841	0.0288	0.4048	0.4215
		[0.2864]	[0.3192]	[0.5182]	[0.2588]	[0.2860]
W. drought, t-1			-0.1460			-0.1655
			[0.3235]			[0.3644]
R2	0.00	0.00	0.01		0.10	0.00
N	9,000	9,000	8,625	8,875	8,875	8,500
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
Model	SEM	SEM	SEM	ArBo	SAR	SDM

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. SEM - Spatial Error Model; ArBo - Arellano and Bond Model (GMM); SAR - Spatial Autoregressive Model; and SDM - Spatial Durbin Model. * - All estimation, apart from the Arellano and Bond model, use maximum likelihood.

1.6.2 Figures

Figure 1-1: The Karamoja Region

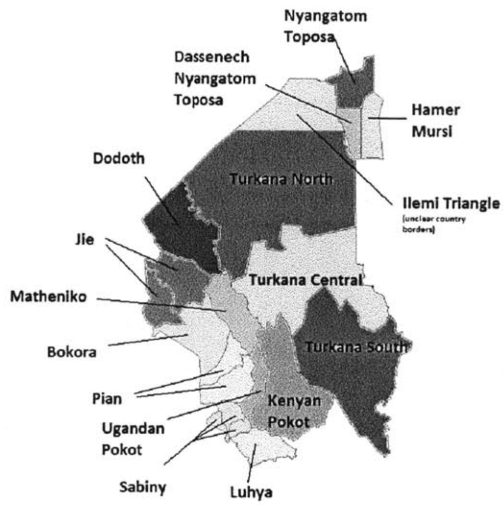

Figure 1-2: The Karamoja Tribes. (Sources include Mkutu (2006) and various NGO reports.)

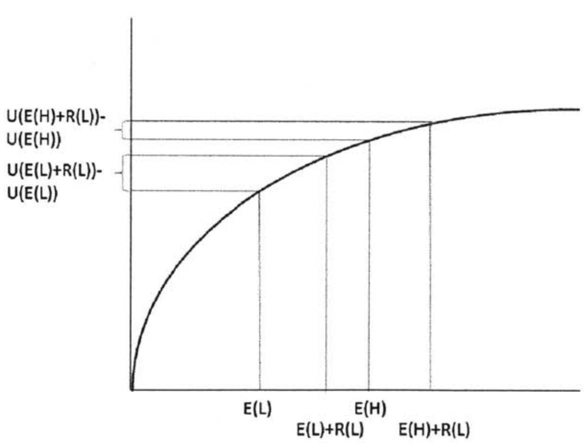

Figure 1-3: Asymmetric increase to resources

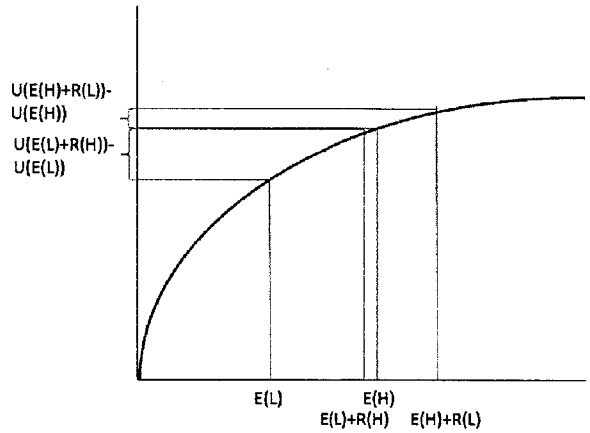

Figure 1-4: Asymmetric resources

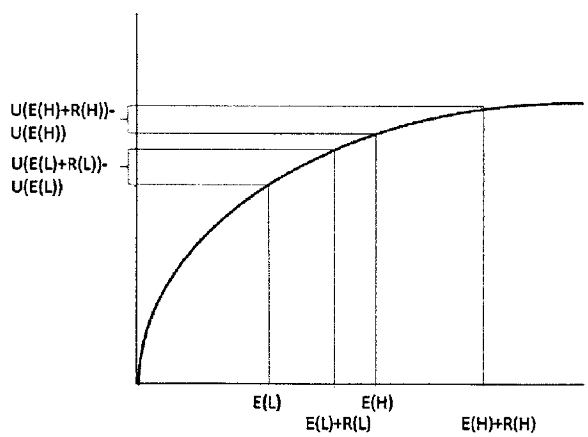

Figure 1-5: Symmetric increase to resources

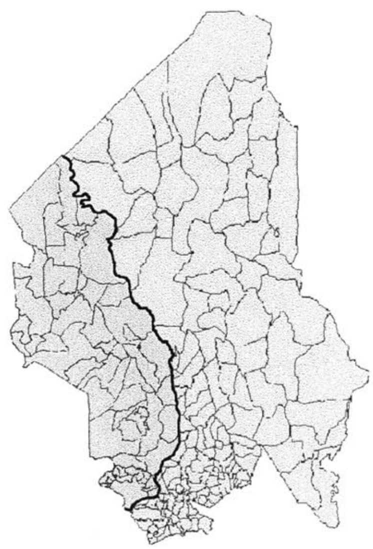

Figure 1-6: Sublocations in Kenya and Subcounties in Uganda

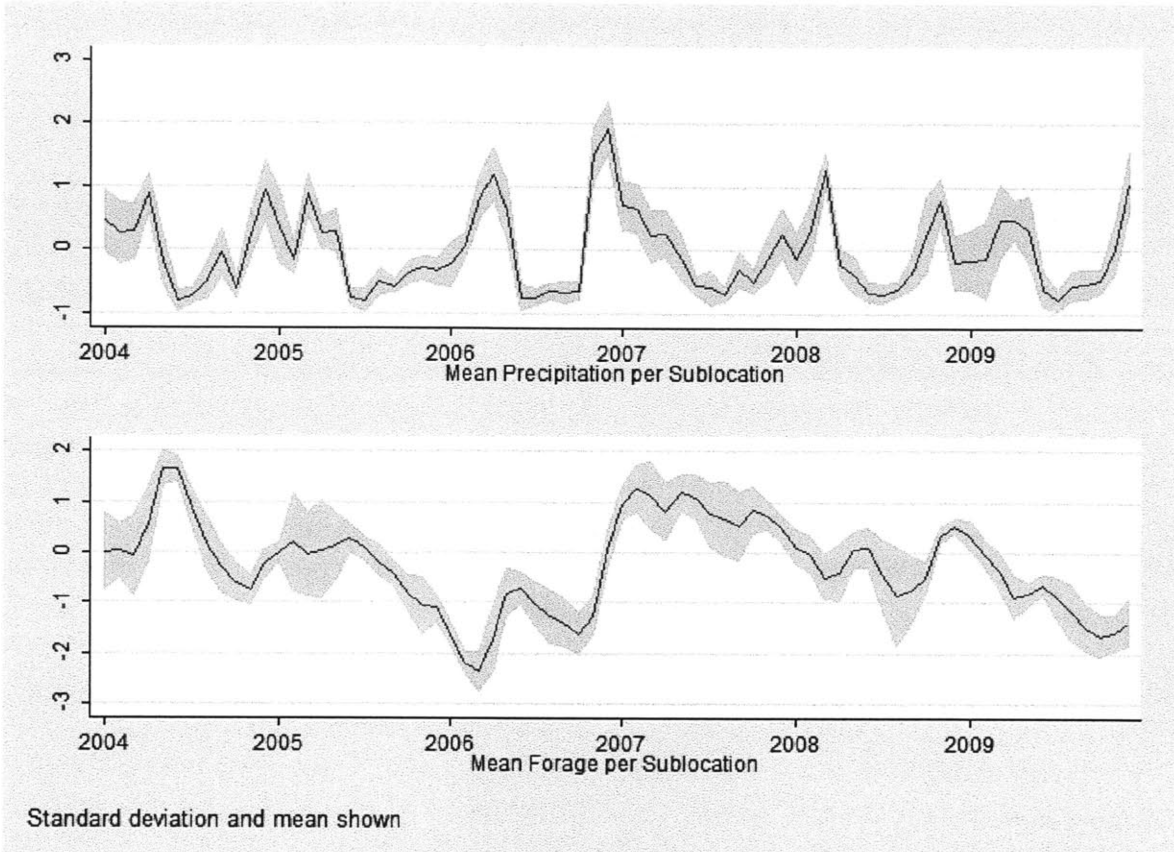

Figure 1-7: Precipitation and Forage Time Series

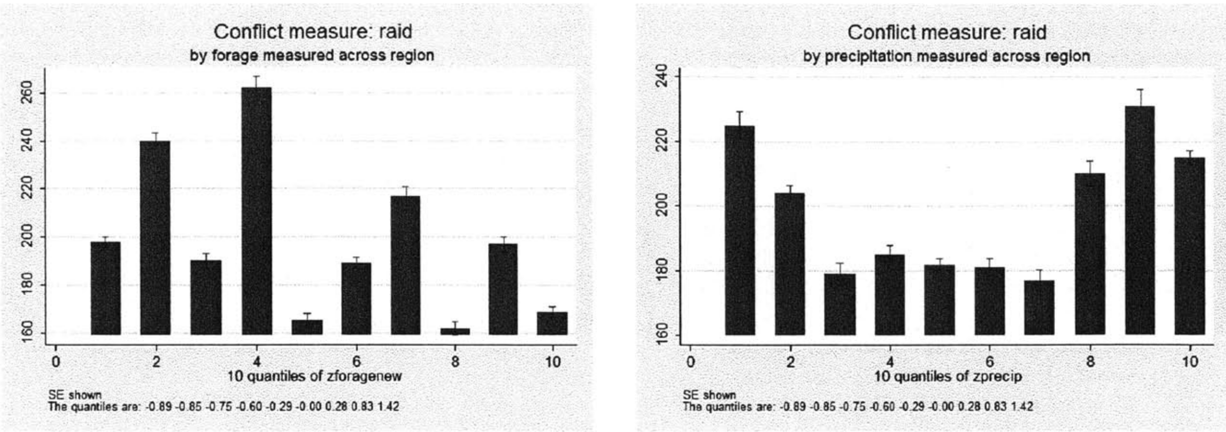

Figure 1-8: Number of Raids by each quantile of Forage and Rainfall across region

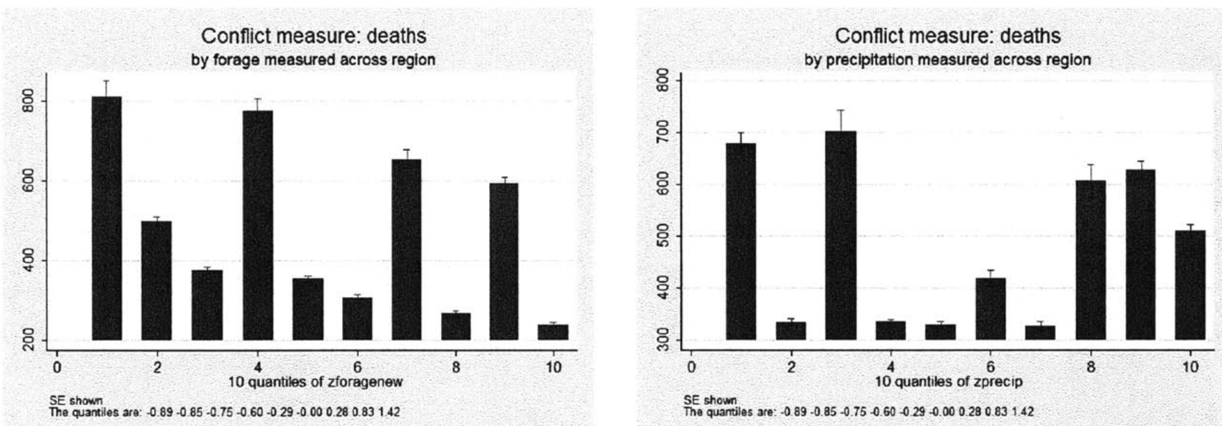

Figure 1-9: Number of Deaths by each quantile of Forage and Rainfall across region

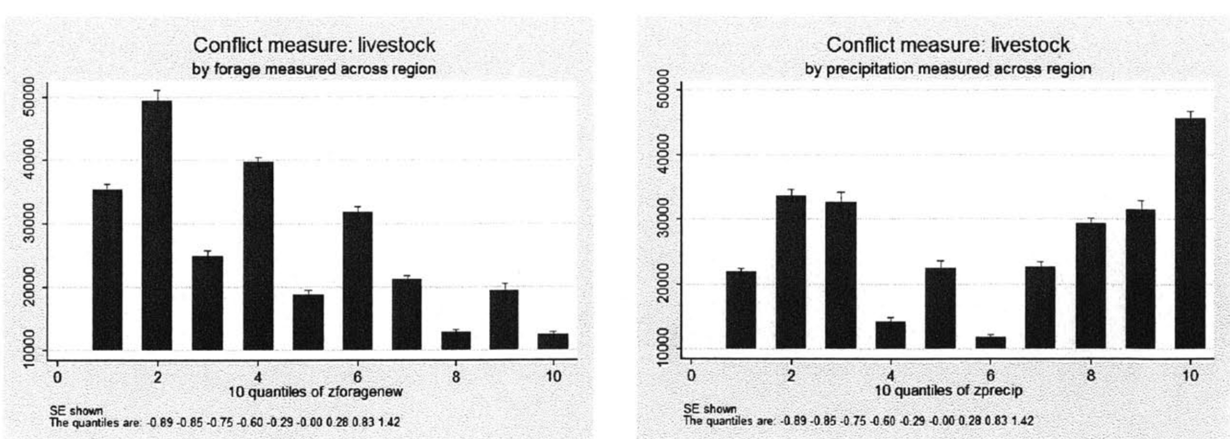

Figure 1-10: Number of Livestock by each quantile of Forage and Rainfall across region

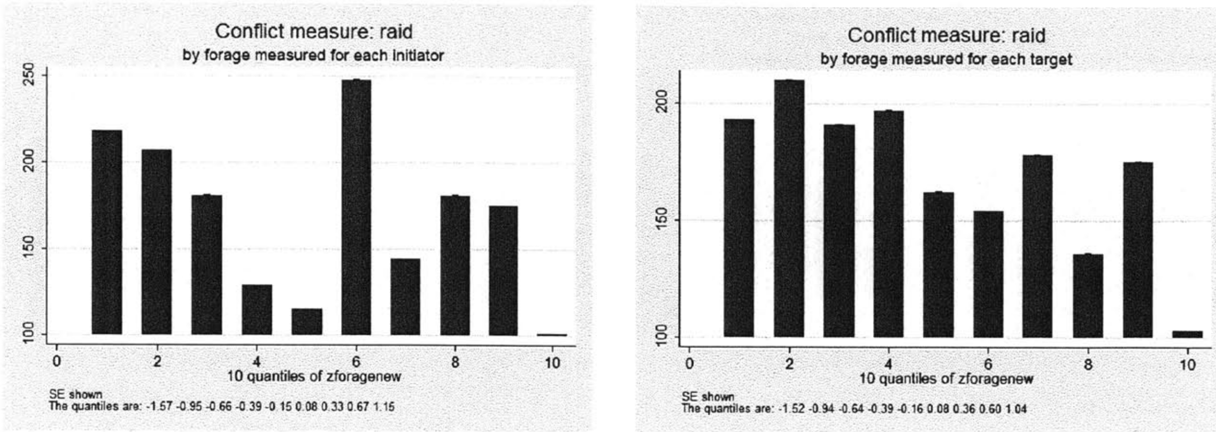

Figure 1-11: Number of Raids by each quantile of Forage for initiating and target tribe

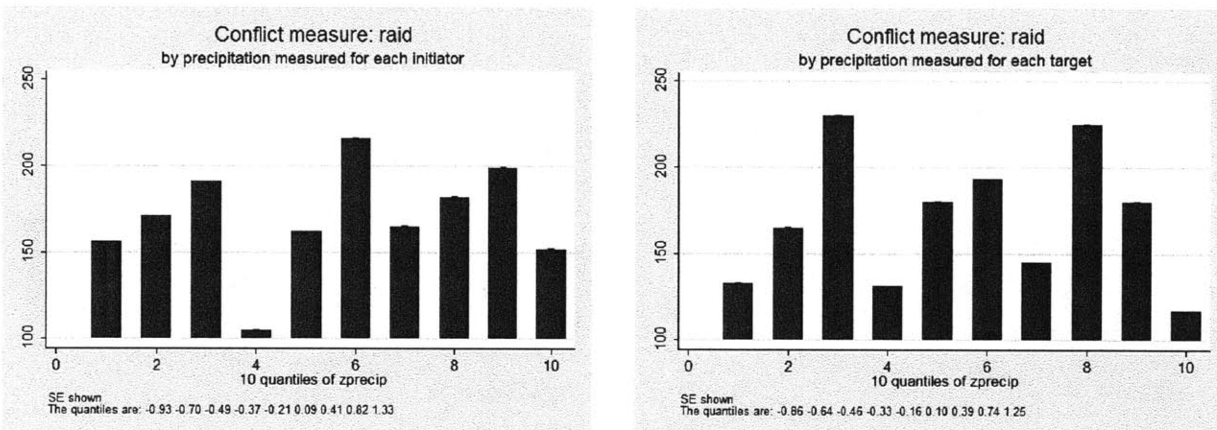

Figure 1-12: Number of Raids by each quantile of Rainfalll for initiating and target tribe

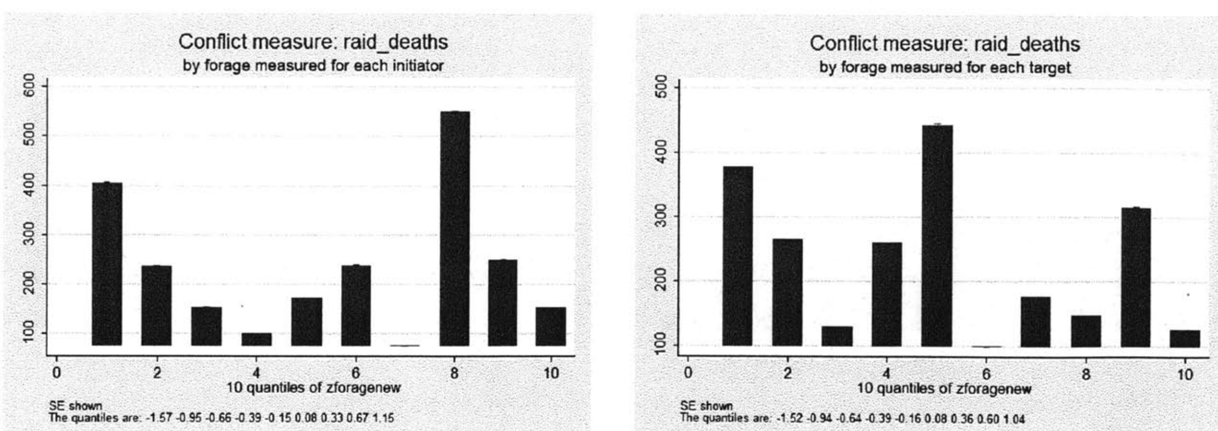

Figure 1-13: Number of Deaths by each quantile of Forage for initiating and target tribe

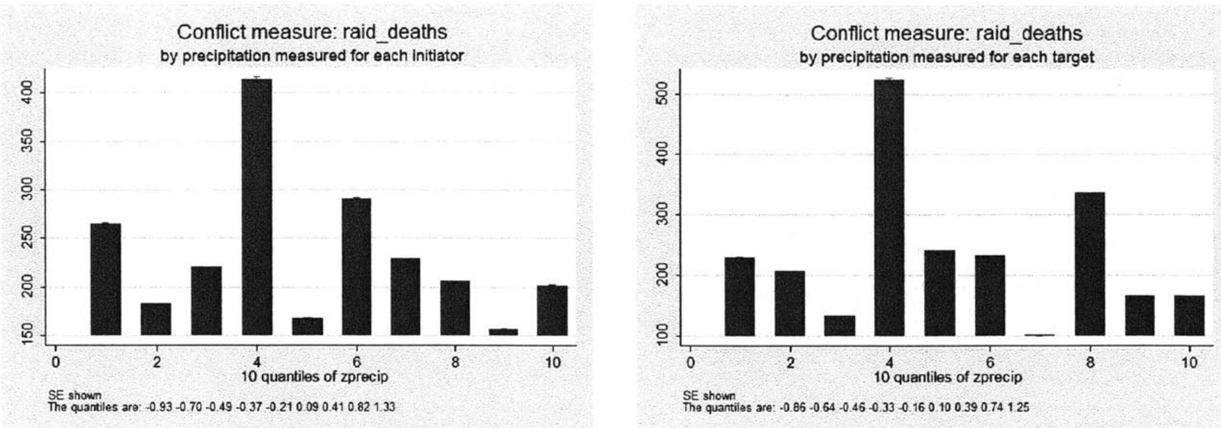

Figure 1-14: Number of Deaths by each quantile of Rainfalll for initiating and target tribe

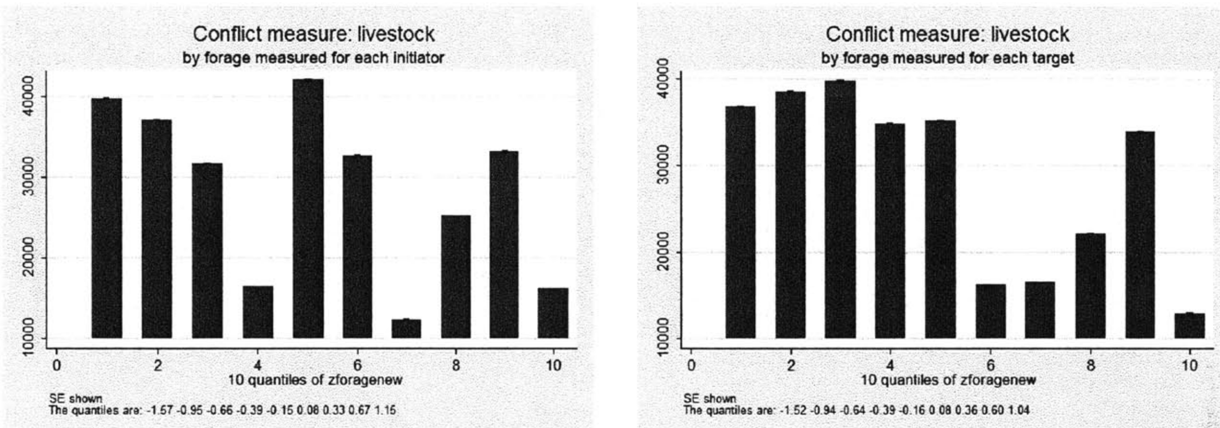

Figure 1-15: Level of Livestock stolen by each quantile of Forage for initiating and target tribe

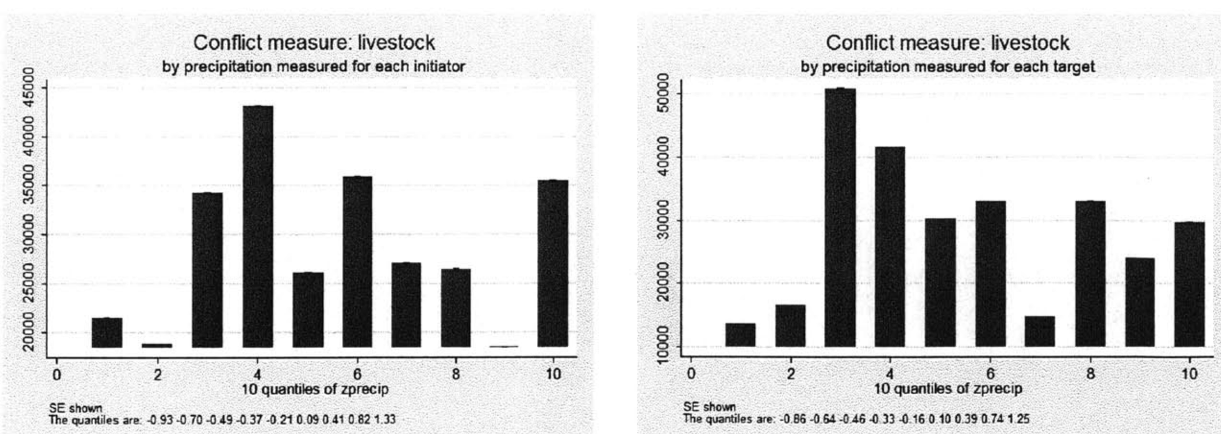

Figure 1-16: Level of Livestock stolen by each quantile of Rainfalll for initiating and target tribe

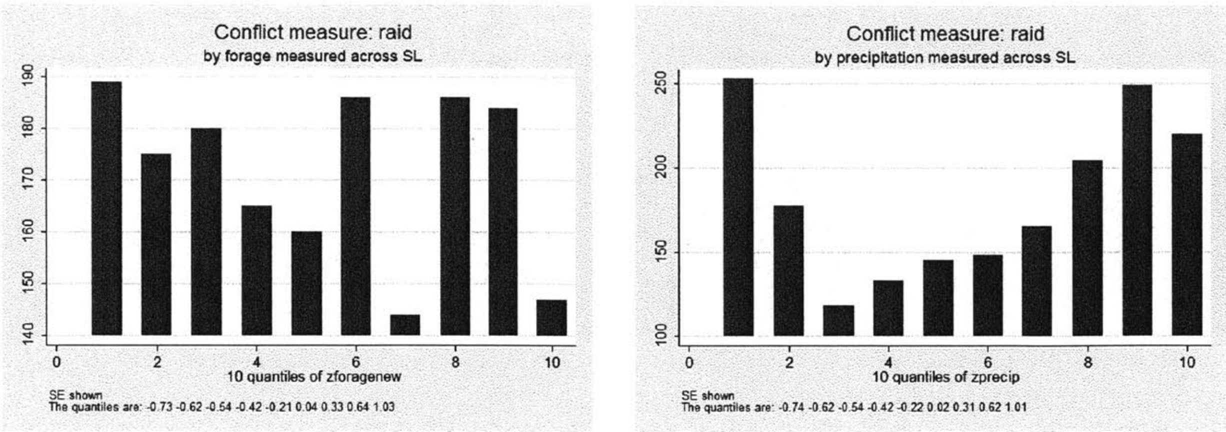

Figure 1-17: Number of Raids by each quantile of Forage and Rainfall in each sublocation

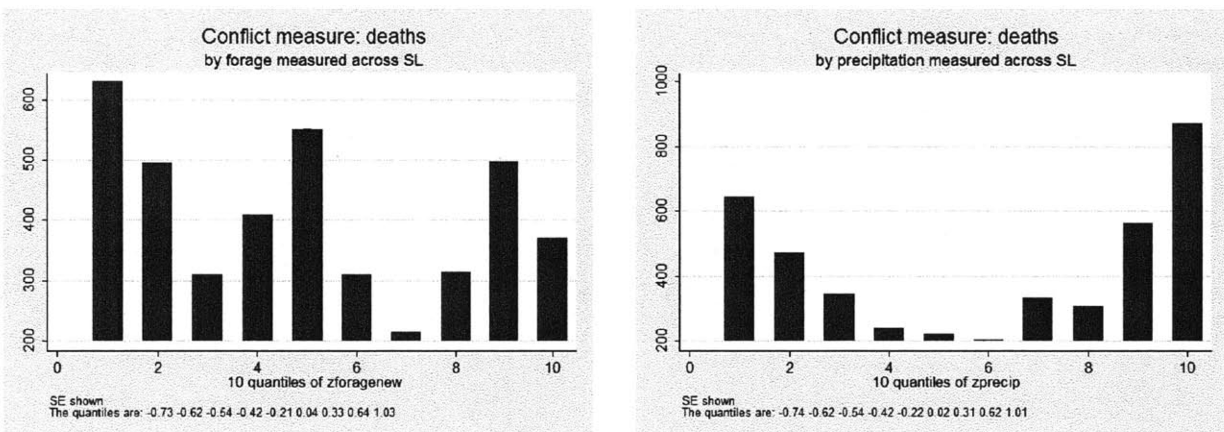

Figure 1-18: Number of Deaths by each quantile of Forage and Rainfall in each sublocation

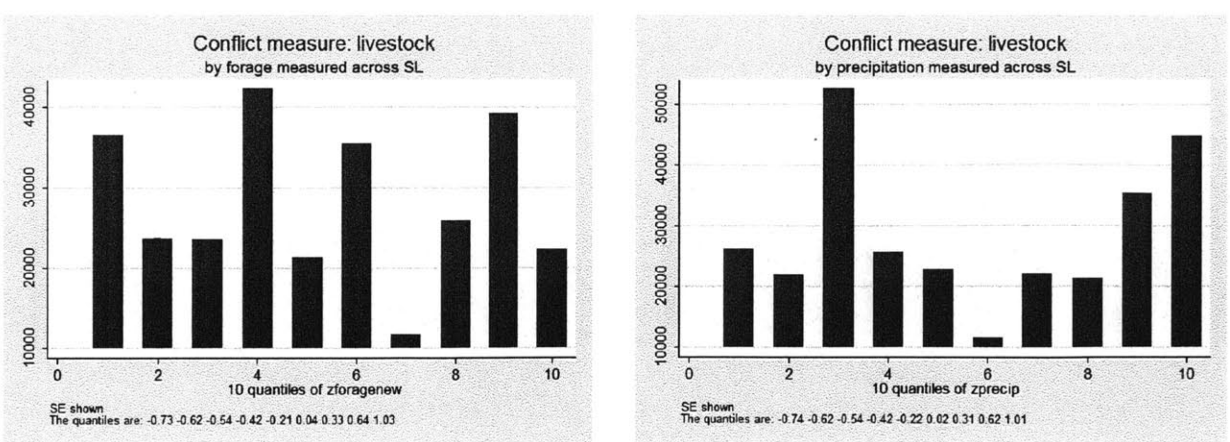

Figure 1-19: Number of Livestock by each quantile of Forage and Rainfall in each sublocation

1.7 Appendix

Table 1.12: Conflict across the Karamoja Region

Dep. Var.: $log(Raids_t)$ OLS			
forage	-0.0305 [0.0501]		
precipitation		0.2100 [0.0831]**	
drought			0.3234 [0.1839]*
N	79	79	79
t-trend	yes	yes	yes
Month FE	yes	yes	yes
SE	NW	NW	NW
Mean of Dep Var	25.18	25.18	25.18

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. NW SE indicates that Newey-West standard errors were computed that allow for heteroskedasticity and autocorrelation up to a degree of 4 lags.

Table 1.13: Conflict across the Karamoja Region

Dep. Var.: $log(Deaths_t)$ OLS			
forage	-0.2580		
	[0.1346]*		
precipitation		0.4465	
		[0.2044]**	
drought			0.5767
			[0.5767]
N	79	79	79
t-trend	yes	yes	yes
Month FE	yes	yes	yes
SE	NW	NW	NW
Mean of Dep Var	61.7	61.7	61.7

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. NW SE indicates that Newey-West standard errors were computed that allow for heteroskedasticity and autocorrelation up to a degree of 4 lags.

Table 1.14: Conflict across the Karamoja Region

Dep. Var.: $log(Livestock_t)$ OLS			
forage	-0.4771		
	[0.1573]***		
precipitation		0.7097	
		[0.2029]**	
drought			0.5550
			[0.6635]
N	79	79	79
t-trend	yes	yes	yes
Month FE	yes	yes	yes
SE	NW	NW	NW
Mean of Dep Var	3366	3366	3366

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. NW SE indicates that Newey-West standard errors were computed that allow for heteroskedasticity and autocorrelation up to a degree of 4 lags.

Table 1.15: Raiding between Tribes in the Karamoja

Dep. Var.: $I(Raids_{ijt} > 0)$						
		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$I(Raids_{ijt-1} > 0)$	0.1426	0.1444	0.1441	0.1163	0.1152	0.1148
	[0.0221]***	[0.0229]***	[0.0228]***	[0.0184]***	[0.0188]***	[0.0188]***
own forage	-0.0104	-0.0067	-0.0035	-0.0177	-0.0010	-0.0030
	[0.0033]***	[0.0060]	[0.0089]	[0.0098]*	[0.0192]	[0.0286]
own forage, t-1			-0.0073			-0.0028
			[0.0091]			[0.0348]
target's forage		-0.0038	-0.0073		-0.0189	-0.0202
		[0.0070]	[0.0110]		[0.0229]	[0.0353]
target's forage, t-1			0.0065			0.0032
			[0.0113]			[0.0393]
own precip	0.0006	0.0020	0.0008	0.0030	0.0021	0.0006
	[0.0032]	[0.0064]	[0.0068]	[0.0095]	[0.0204]	[0.0208]
own precip, t-1			0.0005			-0.0032
			[0.0053]			[0.0163]
target's precip		-0.0016	-0.0017		0.0005	-0.0022
		[0.0065]	[0.0065]		[0.0206]	[0.0210]
target's precip, t-1			0.0048			0.0174
			[0.0050]			[0.0142]
own drought	0.0164	0.0109	-0.0013	0.0530	0.0657	0.0430
	[0.0089]*	[0.0155]	[0.0180]	[0.0361]	[0.0469]	[0.0503]
own drought, t-1			0.0336			0.0709
			[0.0179]*			[0.0408]*
target's drought		0.0079	0.0116		-0.0079	-0.0169
		[0.0152]	[0.0167]		[0.0493]	[0.0475]
target's drought, t-1			-0.0164			-0.0095
			[0.0179]			[0.0459]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Table 1.16: Deaths due to Raids between Tribes in the Karamoja

Dep. Var.: $log(Deaths_{ijt})$						
		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$log(Deaths_{ijt-1})$	0.1385	0.1394	0.1391	0.1315	0.1321	0.1306
	[0.0248]***	[0.0250]***	[0.0251]***	[0.0249]***	[0.0251]***	[0.0252]***
own forage	-0.0042	-0.0104	-0.0062	-0.0086	-0.0271	-0.0434
	[0.0044]	[0.0068]	[0.0113]	[0.0134]	[0.0235]	[0.0391]
own forage, t-1			-0.0059			0.0212
			[0.0111]			[0.0358]
target's forage		0.0066	0.0072		0.0179	0.0343
		[0.0066]	[0.0117]		[0.0256]	[0.0381]
target's forage, t-1			0.0019			-0.0194
			[0.0117]			[0.0347]
own precip	0.0037	-0.0022	-0.0020	0.0165	0.0032	0.0061
	[0.0050]	[0.0072]	[0.0076]	[0.0183]	[0.0230]	[0.0248]
own precip, t-1			-0.0060			-0.0099
			[0.0087]			[0.0303]
target's precip		0.0074	0.0079		0.0130	0.0127
		[0.0065]	[0.0068]		[0.0227]	[0.0247]
target's precip, t-1			-0.0002			0.0028
			[0.0086]			[0.0296]
own drought	0.0426	0.0731	0.0670	0.2160	0.2995	0.2717
	[0.0120]***	[0.0242]***	[0.0245]***	[0.0525]***	[0.0759]***	[0.0746]***
own drought, t-1			0.0158			0.0843
			[0.0175]			[0.0845]
target's drought		-0.0391	-0.0358		-0.1207	-0.1339
		[0.0223]*	[0.0213]*		[0.0852]	[0.0771]*
target's drought, t-1			-0.0130			-0.0106
			[0.0170]			[0.0651]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Table 1.17: Livestock losses due to Raids between Tribes in the Karamoja

Dep. Var.: $log(Livestock_{ijt})$						
		OLS			GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
$log(Livestock_{ijt-1})$	0.1922	0.1910	0.1909	0.1636	0.1620	0.1614
	[0.0282]***	[0.0285]***	[0.0285]***	[0.0241]***	[0.0243]***	[0.0246]***
own forage	-0.0480	-0.0479	-0.0509	-0.1214	-0.1003	-0.2164
	[0.0148]***	[0.0234]**	[0.0376]	[0.0452]***	[0.0991]	[0.1409]
own forage, t-1			0.0000			0.1317
			[0.0411]			[0.1677]
target's forage		-0.0004	0.0052		-0.0211	0.0424
		[0.0264]	[0.0443]		[0.1017]	[0.1636]
target's forage, t-1			-0.0051			-0.0851
			[0.0474]			[0.1854]
own precip	0.0067	0.0136	0.0140	0.0045	0.0510	0.0517
	[0.0144]	[0.0265]	[0.0284]	[0.0414]	[0.0836]	[0.0857]
own precip, t-1			-0.0175			0.0280
			[0.0270]			[0.0793]
target's precip		-0.0067	-0.0103		-0.0464	-0.0501
		[0.0259]	[0.0256]		[0.0859]	[0.0814]
target's precip, t-1			0.0285			0.0161
			[0.0290]			[0.0870]
own drought	0.1270	0.1874	0.1763	0.5811	0.6937	0.6556
	[0.0590]**	[0.0853]**	[0.0937]*	[0.2468]**	[0.2835]**	[0.2987]**
own drought, t-1			0.0260			0.1717
			[0.0743]			[0.2221]
target's drought		-0.0796	-0.0756		-0.1526	-0.1427
		[0.0661]	[0.0743]		[0.2006]	[0.2050]
target's drought, t-1			-0.0143			-0.0856
			[0.0856]			[0.2302]
N	9,360	9,216	9,088	9,230	9,088	9,088
t-trend	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes
SE Cluster	UD	UD	UD	DD	DD	DD

Note: Precipitation is a standardized measure calculated by first finding the standardized level of precipitation in each 0.1 degree grid cell and averaging across all grid cells in the region. Similarly, forage is a standardized measure calculated by first finding the standardized level of precipitation in each 4km x 4km grid cell and averaging across all grid cells in the region. Drought measures the proportion of the 0.1 degree grid cells within no rainfall in the region, and is thus an index between 0-1. UD SE indicates that standard errors were clustered by the i-j undirected dyad and DD SE indicates that standard errors were clustered by the i-j directed dyad. Directed dyad fixed effects are included for all regressions.

Chapter 2

Less Guns, More Violence: Evidence from Disarmament in Uganda

2.1 Introduction

The Karamoja region of East Africa is arguably one of the most violent places in the world as it has a homicide rate that exceeds 50 per 100,000. This is more than ten times as high as the rate in the United States and about three times as high as the Mexican rate (2008 UNODC Homicide Statistics) [44]. The combination of geographical remoteness and hostile environmental conditions make it a difficult area to police and prone to lawlessness, such that violent conflicts tend to escalate. For example, as of August 2006 there were only 137 police officers in the Ugandan part of the region, resulting in a police to civilian ratio of less than 1:7,300, and in March 2004 a total of 300 deaths occurred when a single livestock raid escalated into larger scale conflict between two Ugandan tribes.[1] For comparison, the rest of Uganda has a ratio of about 1:1,800 and the United States has a police to civilian ratio of about 1:450.[2] The Karamoja's proximity to South Sudan and the Democratic Republic of Congo (DRC) has provided the local tribes access to guns, since illegal firearms are trafficked through the region from these countries. At the same time, extreme

[1]Human Rights Watch committee draft report quoted in Get the Gun [99], CEWARN 2004-2009.

[2]Ugandan Official Statistics [45], U.S. Department of Justice [43]

poverty is prevalent, with an estimated 82% of the population in Uganda and 74% of the population in Kenya living below the respective national poverty lines. The predominant form of violence is livestock raids, where a group of tribesmen attack another group with the intention of stealing their livestock - which is the primary source of food in the region. This setting, therefore provides an opportunity to address the role of firearms in a high conflict, insecure and deprived region. In particular, the objective of this paper is to examine whether reducing the number of guns alleviates or exacerbates conflict and instability in this poorly policed environment.

In May 2006, the government of Uganda made a significant forceful effort to confiscate guns, in an attempt "to contribute to human security and promote conditions for recovery and development in the Karamoja" [74]. At this point in time, President Museveni directed the national army to begin "cordon and search" disarmament operations, and guns were forcefully obtained from Karamojan tribesmen. This partial disarmament campaign caused a sharp decrease in the level of firearms in circulation or in use in the Ugandan part of the Karamoja region, as well as an increase in military presence to carry out the campaign. At the same time, there was no comparable policy in the adjacent Kenyan part of the region, despite the two countries sharing a 850 km border, with over 450 km of this border dividing the Karamoja Cluster region.

To analyze the impact of this gun control policy, I first set out a simple model that demonstrates that the impact of the campaign within Uganda is theoretically ambiguous. On the one hand, if conflict is primarily due to an unbalanced distribution of firearms that leads to stronger tribes having a predatory advantage, the disarmament policy could help level the playing field by reducing the number of dominant tribes and therefore reduce the volume of livestock raiding. On the other hand, reducing the aggregate number of firearms in circulation will lower the expected costs of raiding for all tribes since any tribe will be less likely to confront a highly armed tribe when they initiate a raid. This will increase the incentive to participate in livestock raiding and could lead to an overall increase in raiding, outweighing the previous effect, particularly if tribes who were initially not raiding start to raid.

To examine this empirically, I evaluate the impact of the disarmament campaign on violence, comparing sublocations in Uganda to non-border sublocations in Kenya over time. I find that the disarmament campaign led to an increase in the frequency of raids in Uganda by at least 40%. At the same time the number of deaths caused per raid decreased so that the total number of deaths was not significantly affected by the campaign. These findings suggest that the disarmament campaign led to a decrease in the costs of raiding, as measured through costs to human life, but that in this setting the deterrent role of guns dominated their role in facilitating violence so that an unintended consequence of the campaign was to increase participation in raiding, rather than reduce it.

Furthermore, with the detailed tribe-level conflict data I have obtained, I am able to examine whether the campaign had any impact on violence occurring across the Kenya-Uganda border. For example, I can address whether or not it influenced either Kenyan raids on Ugandans or Ugandan raids on Kenyans in border sublocations. Interestingly, I find no evidence that the campaign increased Kenyan raids on Ugandans, but I do find that after the campaign there was a decrease in the frequency of cross-border raids by Ugandans on Kenyans by about 60%. The first finding that there was no increase in Kenyan attacks on Ugandans, coupled with the earlier results, shows that the increase in raids in Uganda was not driven by any spillover effects the campaign may have had on Kenyans, while the second finding that there was a decrease to Ugandan attacks on Kenyans shows the campaign may have encouraged Ugandans close to the border to raid other Ugandans, rather than Kenyans, providing further evidence of the use of guns for deterrence at least among Ugandan tribes.

There are several appealing features to this study. First, the control group (Kenyan Karamojans) share many common characteristics with the treatment group (Ugandan Karamojans). These tribesmen come from the same ethnolinguistic groups - the Aketer subdivision of the Eastern Nilotic linguistic group, and follow the same methods of nomadic pastoralism as their primary livelihood. It was only during colonization at the turn of the 20th century that national borders were formalized and these tribes were separated between the two countries. Second, survey measures of firearms clearly demonstrate that after the disarmament campaign, there was a weapons reduction and the circulation of bullets decreased in Uganda but not Kenya. Third, as well as examining the impact of a reduction in firearms, the results from this paper can help us learn about the effectiveness of military and government interventions in a high conflict environment with weak institutions.

Few papers have looked directly at the impact of gun control on violence in developing countries. Dube et al. (2011) [8], studies the impact of more lenient gun sales laws in Texas and Arizona on homicide rates in Mexico border municipios. They find an increase in firearm deaths in the Mexican municipios, which they attribute to a rise in gun supply. However, there is no indication of what might have happened if the government of Mexico had attempted to intervene, nor is it obvious that a reduction in the supply of guns would have had the opposite effect. To my knowledge this paper is the first to directly study a disarmament effort in a developing country.

There is a developed literature on the impact of gun control laws in the US. While there is not complete consensus on whether allowing people to carry guns increases or decreases crime, most recent work has indicated that guns tend to facilitate violence in the US rather than deter it. For example, empirical studies using proxy measures for gun ownership, such as the regional sales variation in gun magazines (Duggan 2001) [30]) or suicide rates (Cook and Ludwig 2005) [25], suggest there is a positive causal relationship between gun ownership and the homicide rate, with this result being mostly driven by an increase in murders in which a gun is used, lending evidence to the argument that an increased availability of firearms facilitates the ability of criminals to carry out violent crime. Other studies by Dezhbakhsh and Rubin (1998) [26], Dezhbakhsh and Rubin (2003) [27], Black and Nagin (1998) [14], Ludwig (1998) [57], and Ayres and Donahue (2003) [28] have similarly concluded that allowing people to carry guns increases crime.[3] While this paper relates to this literature, it asks a rather different question, since this paper questions what impact gun policies have when there is a much higher risk that an individual will need to defend themselves from a violent attack and in a situation where there is limited capacity of the state to protect individuals, or to retribute offenders. Given these differences, it is not obvious that my results should match the results of studies based on gun policies in the US.

This paper also relates to the literature on civil conflict in developing countries in that it focuses on intranational conflict in a weak institutional environment. That literature has identified a strong correlation between negative income shocks and the onset or continuation of civil conflict, and

[3]There are a few studies that assert the opposite: Lott and Mustard (1997) [56], Bronars and Lott (1999) [18], Benson and Mast (2001) [10], Plassmann and Tideman (2001) [77] and Lott (2003) [55].

attributed this correlation to both limited state capacity to contain violence and lower opportunity costs of participating in violence (Fearon and Laitin 2003 [36], Collier and Hoeffler 1998 [24]). This paper enhances this area of research by addressing a new question: given that conflict is prevalent, do guns lead to more or less violence? Thus it speaks to the more nuanced question: how much conflict will there be, rather than asking: will there be conflict?

The remainder of this paper is organized as follows. The first section discusses in more detail the background of the Karamoja Cluster region, the type of violence prevalent in the region, and how the disarmament campaign was carried out. The second section describes the conflict data. The third section outlines a theoretical model to frame the analysis. The fourth section outlines the empirical strategy and presents the results. Section five, discusses the findings and outlines some implications of this study.

2.2 Background

This section provides background information on the Karamoja region to illustrate both the importance of livestock in the region and to highlight the evolution of violence that has led to it becoming an extremely insecure environment. I also discuss similarities between the Kenyan and Ugandan parts of the region and how they were only recently separated during the British colonization of East Africa, before describing the details of the disarmament campaign that is the focus of this paper.

2.2.1 Physical and Human Geography

The Karamoja Cluster is located across the borders of Uganda, Sudan, Ethiopia and Kenya, covering an area of 25,000 square miles and has a human population estimated to be between 1 and 1.6 million (see Figure 2-1). The region is described as arid or semi-arid savannah, with high average daytime temperatures, low and unpredictable rainfall and pronounced seasonality. Tribal communities populate the region: in Uganda, most tribes belong to the Karamojong ethnic group, which can be further divided into the Dodoth, Jie, Pian, Matheniko and Bokora; in Kenya, the predominant tribal group are the Turkana; and an ethnic group known as the Pokot live in the southern parts of the Cluster across the Kenya-Uganda border (see Figure 2-2) (Gartell 1985 [38], Quam 1997 [79], Gray et al. 1999 [86], Powell 2010 [78]). All these tribes are closely ethno-linguistically related and come from the same Aketer subdivision of the Eastern Nilotic linguistic group (Ethnologue 2011) [2]. Thus, they are linguistically intelligible to each other, and share much history and culture.

Statistical indicators for the region are suggestive of extreme poverty and deprivation. An estimated 82% of the population in Uganda and 74% of the population in Kenya live below the corresponding national poverty lines. Less than half the population have access to safe drinking water, less than a third have access to sanitation units, and most of the region surpasses the World Food Organization's emergency threshold for malnutrition rates. Similarly, statistics on other health indicators and literacy rates are very low (see Table 2.1).

The traditional livelihood, and that which is still practised today, is nomadic pastoralism whereby cattle and livestock are raised to provide a diet of meat, milk and blood to their owners. While some grain, such as sorghum and millet, may be grown in small amounts to supplement their diet, the pastoralists rely heavily on their livestock as their primary source of nutrition. Livestock also provides a measure of wealth, and bride prices are denominated in livestock. For many years this practice of transhumance pastoralism was the most effective method of subsistence in the region, but population growth, longer and more severe drought periods, and restrictions on the movement of pastoral groups due to the encroachment of commercial agriculture, have made the pastoral livelihood more difficult to sustain (Gray et al. 1999 [86]; Little 1999 [54]).

2.2.2 Historical Context

While the British established their influence over the most productive regions of East Africa in the 1890s, the Karamoja Cluster was largely left untouched as the remote and inhospitable region offered few benefits to the colonists. However, due to the risk of livestock diseases spreading and the unauthorized presence of Ethiopian ivory traders in the Karamoja Cluster, which until then had been creating a buffer between British East Africa and the Ethiopian empire, the British decided to establish a military administration in Karamoja in 1911. These colonial borders formalized the separation between the Kenyan Karamoja and the Ugandan Karamoja and also created borders within the countries that arbitrarily assigned permanent territorial rights based on whichever tribe was predominant in the area when the boundary was set. This triggered an increase in hostility between the Turkana, Pokot and Karamojong tribes that has grown over time, and isolated the region from the rest of Kenya and Uganda, generating "closed" districts where movement within and outside was restricted without a valid pass (Quam 1997 [79], Knighton 2003 [49], Gray et al. 1999 [86]).

In 1954, the British launched an accelerated program of agrarian reform and tried to transform the traditional livelihood into Western ranching schemes. However, the effect of this intervention intensified overgrazing and desertification, and further aggravated inter- and intra-tribal tensions. After independence settlement policies were still pursued, since settlement was perceived to be the most suitable solution to the problems of environmental degradation. However, the region was excluded from road communication and infrastructure projects that pervaded the rest of Uganda and Kenya, and so the communities continued to prioritise their prior tribal identities rather than identifying with the newly formed states. From the 1970s a series of droughts and livestock disease epidemics have plagued the region, and detrimentally impacted livestock and human populations [86], [78]. [4]

2.2.3 Conflict and Arms

The earliest records of arms in the region date to 1900s when the pastoralists engaged in trade with Ethiopian ivory poachers, who supplied guns in return for ivory, or safe passage across the region. These weapons were used for livestock raiding - a traditional activity whereby groups of young men would attack a neighboring tribe, after obtaining a blessing from the elders of their tribe, with the intention of bringing back additional livestock. These raids were part of the pastoralists' culture, as they were often used to mark the coming of age of a young boy into manhood, and were activities under the control of the tribal elders. It was convention for the elders to forewarn

[4]The most notable multi-year droughts occurred in 1967-68, 1974-75, 1979-81, and 2010-2011.

the target community of an impending raid, and deaths to women and children were deplored. Some anthropologists have claimed that the raids helped redistribute an unequal distribution of livestock when one tribe had been more severely affected by a drought or a disease epidemic, and that there was an implicit understanding between tribes that this aggression could be expected (Hendrickson, Armon and Mearns 1998) [31]. However, in more recent years the social structure of the tribes appears to have broken down, and the decision to raid is made unilaterally by bands of young men who have guns. While they still identify with their ethnic tribal group (i.e., they call themselves the Dodoth, or the Jie warriors), and they do not raid from their own tribe, they no longer seek permission from their tribe's elders, and spend much time away from the tribal communities, effectively as roaming criminals (Akabwai and Ateyo 2007) [4].

More guns entered the region when the British recruited the Karamojong and Turkana tribesmen to fight in the East African Brigade during the Second World War and inadvertently provided them with guns to use when they returned to their tribal communities. A second influx of weapons occurred when the Amin regime collapsed in 1979 and the Matheniko were able to loot the government amory in Moroto, obtaining large quantities of small arms and ammunition. Current regional gun flows operate through the Sudan-Uganda and Sudan-Kenya border, where the Didinga and Toposa pastoralists of Southern Sudan have obtained small arms through a variety of means related to the Sudanese Civil War.[5] There are also claims that raiders in the west of the Karamoja obtained weapons by either trading them with the Lord's Resistance Army (LRA) rebels, or through overcoming the LRA during raids and appropriating their guns (Small Arms Survey 2006) [1].

It is difficult to put a precise figure on the number of firearms in the region, given the illegality that most weapons have entered the region illegally. Estimates range from 30,000 to 200,000 around 2005 (the period before the disarmament policy was introduced).[6] To summarize the current situation in the region, the steady rise of firearms in the region, coupled with environmental

[5]For example, by the alleged direct transfer by the Government of Sudan (GoS) in order for the Didinga and Toposa to help destabilize the Sudan's Peoples Liberation Army (SPLA) during years of the Sudanese Civil War, or from gun sales by deserters of both the GoS or SPLA forces, or from looting border garrisons as they repeatedly changed hands between the two forces (Mkutu 2007 [69], Akabwai and Ateyo 2007 [4]).

[6]The UPDF (2007) [95] claims a figure of 30,000 weapons. As Mkutu (2007) [69] notes, most estimates range from 40,000 to 80,000 with some (media) suggesting as many as 200,000.

pressures and degradation of natural resources, as well as isolation from human development initiatives, such as health care facilities and roads, has left the region marginalized and in a state of insecurity and chaos. Predatory raiding where groups of young tribal warriors initiate raids are common.

2.2.4 Disarmament

The first attempt since independence to reduce the number of guns in the Karamoja Cluster began with a voluntary disarmament campaign initiated by the Government of Uganda in December 2001. The intention of this campaign was to increase security to pastoralists by limiting the ability of each tribe to participate in raiding activities. The campaign involved the voluntary hand over of guns in return for sheets of corrugated iron roofing and certificates noting the surrender of weapons by an individual or family. This campaign had mixed success. The Government of Uganda claimed to obtain nearly 10,000 guns within a two month period (KIDDP 2007) [74], but the gifts of iron sheets made compliant tribesman vulnerable to attack, as they became readily identifiable as people who had disarmed. In response to the targeted raiding on the disarmed tribemen, the Uganda People's Defence Force (UPDF) chose to re-arm some communities and form so-called Local Defence Units (LDUs), so it is ambiguous how many weapons were physically removed from the region. Between March 2002 and June 2003, the Lord's Resistance Army attacks intensified in the northern districts of Uganda to the west of the Karamoja Cluster. This forced the UPDF to withdraw from the region and rapid re-armament occurred with young men being sent into Southern Sudan to purchase more guns and ammunition (Akabwai and Ateyo 2007) [4].

The subsequent raids and counter raids that erupted following the failed 2001-2002 disarmament initiative resulted in the Ugandan government discussing the launch of another attempt at disarmament. Local civil society organizations, international NGOs, and the Karamojong themselves asked the government to address not only the quantity of guns in circulation, but the other causes of insecurity, such as the marginalization of traditional livelihoods and the increased environmental pressures. However, following the presidential elections in February 2006, when Museveni gained power for a third term, the Government of Uganda disarmament strategy took an unexpected and wholly military character. While there had been discussions on how to address insecurity in the region, the general view gathered from firsthand interviews with member of parliaments, opposition leaders and the Karamojong themselves was that the reason for staging these discussions was an attempt by the Museveni regime to buy votes, and tribesmen reported, "Recovery of guns is in theory. There is nothing going on." [4]. However, starting in May 2006, the UPDF introduced what they termed "Cordon and Search Operations", and communities were effectively occupied by the military until the UPDF were satisfied with the number of guns that had been surrendered [4].[7] By 2008, the UPDF announced they had recovered 30,000 guns from the region, although their activities were concentrated in the months immediately after May 2006. Ugandan media reports suggest that the price of AK-47s and bullets increased fivefold during this disarmament campaign (Bevan 2008a) [12]. Over the same period, there was no active disarmament in Kenya.[8]

I focus on the disarmament that occurred in Uganda starting in May 2006 because it was unexpected in its timing, and it had a significant immediate impact on the number of firearms in circulation due to the nature in which it was implemented. Specifically, I compare the 12 months prior to May 2006 and the 12 months afterwards in both Uganda and Kenya, to examine the impact of the disarmament campaign on the frequency of livestock raids and the lethality of violence.

2.3 Data

The conflict data comes from CEWARN (Conflict Early Warning and Response Mechanism), a recent initiative that was set up by the Intergovernmental Authority on Development (IGAD) to monitor, prevent escalation or mitigate the worst effects of violent conflicts. CEWARN collects detailed accounts of all episodes of pastoral conflict and crime in the Karamoja Cluster by using

[7]The international donor community has shown concern over the brutality of the UPDF's actions, and there have been allegations of abuse and torture to civilians in the region.

[8]Instead, if anything, there was informal arming of local tribesmen by the Kenyan government on a small scale to form the Kenya Police Reserves (KPR), which were supposed to play a similar role to the Local Defence Units (LDUs) in Uganda. In this case, the KPR are supposed to protect local communities against raids by the Sudanese Toposa and the Ugandan Karamojong tribes (Bevan 2008b) [11].

field monitors to record reports of these incidents.[9] These incident reports are coded by the level at which the information was obtained, and over 90% of the reports have either the field monitor as a direct observer, or the informant to the field monitor as a direct observer. The remainder are compiled based on police, newspaper, or radio reports.

The incident reports are extremely detailed and record the type of crime (cattle raid, livestock theft, banditry, assault, abduction, murder or rape), the date each crime occurs, the number of people involved, the outcomes to human life and property (such as the number of livestock taken), the tribes involved (who was the initiator and who was the target), and the location of the crime (up to the village level).[10] Therefore, using this data I am able to undertake a micro-level approach to understanding conflict and disarmament. I focus on the livestock thefts and raids, because they are the most salient form of violent crime in the region.

As well as the incident reports, I have access to survey data on the level of bullets in circulation and the impact of the disarmament policy. This is because the field monitors complete a 55 question survey at a weekly frequency to aid CEWARN in its ability to forecast outbreaks of violence and the survey contains questions relating to bullets and disarmament. Between May 2005 to April 2007, the 12 months before and after the disarmament campaign, there were 5 field monitors in Kenya and 7 in Uganda. The incident reports can also be used to trace the movements of the UPDF during their disarmament operations, since the reports record incidents where the military used excessive force to disarm communities, or when the operations led to deaths or injuries to either the military or civilians.[11] Based on firsthand interviews by researchers in the area [4], the majority of the disarmament operations were described to involve excessive force by the UPDF.

I have matched the incident reports to the International Livestock Research Institute's detailed administrative maps for the region to obtain the rate of raids, deaths and livestock stolen per month

[9]Field monitors are CEWARN employees and must be able to speak the local dialects in the region they are deployed. However, they must be literate and are not natives of the region.

[10]Within Kenya, the taxonomy of geography is: country, province, district, division, location, sublocation, village; while in Uganda the taxonomy is: country, district, county, subcounty, village. For this study, I use sublocations in Kenya and subcounties in Uganda, as my geographic unit of analysis, and I adopt the Kenyan term "sublocation" for this geographic unit.

[11]A total of 93 disarmament operations can be traced through the incident reports, of which 29 led to deaths, and of these 3 led to more than 10 deaths.

per sublocation. A map of the sublocations in Kenya and Uganda can be seen in Figure 2-3, and descriptive statistics on selected conflict and pastoral indicators are covered in Table 2.2.

2.4 Theoretical Framework

This section formalizes the intuition that the disarmament campaign could have an ambiguous impact on conflict within Uganda using a simple model. The model describes a setting in which tribes are either heavily armed or weakly armed, and the purpose of the campaign is to reduce the arms level of heavily armed tribes in order to eliminate their predatory advantage over the weakly armed tribes. However, if the campaign is effective in this goal, the expected costs of participating in conflict for both tribes will also change and this may inadvertently cause an increase in raiding. In other words, fewer tribes will be deterred from raiding. Thus, this model gives rise to multiple outcomes, where different levels of raiding occur dependent on the proportion of heavily armed to weakly armed tribes in the region.

The model description matches some basic features of the conflict data that will be discussed in more detail in the section four. But for now, to illustrate why I chose this model set-up, consider that there is geographic variation in the proximity of tribes to the Sudanese border - a potential source of weapons, that some tribes raid far more than others and that the military carried out more cordon and search operations on these tribes.[12]

In the remainder of this section, I will provide details on the set-up to the model and then show several predictions.

2.4.1 Set-up

The structure of the model is as follows. There are two levels of arms in Uganda. A proportion p of tribes have a high level of arms $\overline{G}$, while $(1-p)$ have a low level of arms $\underline{G}$. For notational convenience I will refer to these tribes as H-types and L-types. When a tribe makes the decision to

[12]Figure 2-4 illustrates this targeting by the military, while Figure 2-1 demonstrates the proximity of the Karamoja region to South Sudan.

raid they know their own arms level but not the level of arms of the opponent they will meet. The proportion of H-types in the population, p, is common knowledge.

Each period one randomly selected tribe will decide whether or not to raid. The geographic dispersion of tribes makes it unlikely that a tribe could strategically choose to raid another tribe when that tribe is also raiding, leaving their livestock less well guarded. In addition, the frequency of raiding observed in the data is low enough that it is rare to observe more than one raid per day in the region.[13] Given this, I choose not to allow for raids to occur simultaneously, whether strategic or non-strategic, in the model.

When a tribe is attacked they always attempt to resist the aggressor, so initiating a raid is never costless for either type of tribe. This is observed in the data, since the textual accounts of raids almost always describe resistance by the target and about 25% of all raids lead to at least one death. The spoils to raiding are denoted by B and can be thought of as the average number of livestock obtained. If a tribe initiates and wins a raid they obtain B, but they obtain nothing if they are unsuccessful. If a tribe is attacked and unsuccessfully defends a raid, they lose B, while they retain B if they successfully resist the attack.

The cost of raiding is incurred by both the aggressor and the defendant, and it depends on both parties' arms level: $C(G_1, G_2)$, where the first argument denotes the tribe's own arms level and the second argument denotes the opponent's arms level. The cost function is not symmetric unless $G_1 = G_2$ as when tribe 1 attacks tribe 2 they incur cost $C(G_1, G_2)$, while tribe 2 incurs cost $C(G_2, G_1)$ when defending against this attack. The cost of fighting decreases in a tribe's own arms level ($\partial C(G_1, G_2)/\partial G_1 < 0$), increases in the arms level of the opponent ($\partial C(G_1, G_2)/\partial G_2 > 0$), and increases in the aggregate amount of arms. This implies: $C(\underline{G}, \overline{G}) > C(\overline{G}, \overline{G}) > C(\underline{G}, \underline{G}) > C(\overline{G}, \underline{G})$.[14]

I assume that the probability the initiating tribe makes a successful raid is determined by the

[13] About 10% of recorded raids between 2004-2009 in Uganda occur on the same day.

[14] Most of the conflict costs recorded in the data match this ranking. Using the level of raiding in the 12 months before the campign to classify tribes as H-types and L-types, I find that the average number of deaths reported when a L-type is attacked by a H-type is 1.35, while it is 0.93 when a L-type attacks a H-type. Raids between two H-types incur on average 1.07 deaths, while it about 0.8 for L-types. Given that it is easier to monitor the number of deaths to targets, these statistics are consistent with the conflict cost ranking that I suggest in the model.

ratio of the two tribes' gun levels. Explicitly, the probability tribe 1 is successful against tribe 2 is: $G_1/(G_1+G_2)$, and the probability tribe 2 successfully defends themself from tribe 1 is: $G_2/(G_1+G_2)$.

I also assume that $\frac{\overline{G}}{\underline{G}+\overline{G}}B - C(\overline{G},\underline{G}) > 0$, so that the H-types will always be willing to fight L-types if they could observe their type, and $\frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G}) < 0$, so that the L-types will never choose to fight H-types, again, if they could observe their type.

The disarmament campaign is assumed to target the heavily armed tribes and lower their arms level to that of a L-type.[15] This implies that it reduces p, the proportion of H-types in the population. I can now state the first result:

Proposition 1

There is a threshold, $\chi_1(B,\overline{G},\underline{G})$, such that no raiding occurs if $p > min(\chi_1, 1)$.

Proof. H-types' incentive to raid requires that their expected net gains to raiding are positive:

$$p\left(\frac{1}{2}B - C(\overline{G},\overline{G})\right) + (1-p)\left(\frac{\overline{G}}{\underline{G}+\overline{G}}B - C(\overline{G},\underline{G})\right) \geq 0$$

If $\frac{1}{2}B - C(\overline{G},\overline{G}) \geq 0$, then H-types will always raid, since $\frac{\overline{G}}{\underline{G}+\overline{G}}B - C(\overline{G},\underline{G}) > \frac{1}{2}B - C(\overline{G},\overline{G})$.
If $\frac{1}{2}B - C(\overline{G},\overline{G}) < 0$, then H-types will not raid if p is above the threshold χ_1, where:

$$\chi_1 = \frac{\frac{\overline{G}}{\overline{G}+\underline{G}}B - C(\overline{G},\underline{G})}{\left(\frac{\overline{G}}{\overline{G}+\underline{G}}B - C(\overline{G},\underline{G})\right) - \left(\frac{1}{2}B - C(\overline{G},\overline{G})\right)}$$

□

As p decreases the probability that an initiating tribe meets an H-type when they raid decreases, while the probability they meet with an L-type increases. This increases the expected gains to

[15]It seems plausible that the tribes can either keep hidden a small number of guns or restock to the low level so I assume the arms level of L-types is maintainable.

raiding for both tribes, and may lead to L-types raiding as well as H-types. This effect is outlined in my second result:

Proposition 2

There is another threshold, $\chi_2(B,\overline{G},\underline{G})$, such that once $p \leq max(0,\chi_2)$, L-types will raid as well as H-types.

Proof. For L-types to choose not to raid, their expected net gains to raiding must be negative:

$$p\left(\frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G})\right) + (1-p)\left(\frac{1}{2}B - C(\underline{G},\underline{G})\right) < 0$$

If $\frac{1}{2}B - C(\underline{G},\underline{G}) < 0$, then L-types will never raid for any value of p as $\frac{1}{2}B - C(\underline{G},\underline{G}) > \frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G})$.

If $\frac{1}{2}B - C(\underline{G},\underline{G}) \geq 0$, then L-types will raid once p is below the threshold χ_2, where[16]:

$$\chi_2 = \frac{\frac{1}{2}B - C(\underline{G},\underline{G})}{\left(\frac{1}{2}B - C(\underline{G},\underline{G})\right) - \left(\frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G})\right)}$$

□

These two propositions show that the level of raiding in Uganda depends on the proportion of heavily armed to weakly armed tribes in the region as well as the relative benefits and costs of raids. If $\frac{1}{2}B - C(\overline{G},\overline{G}) < 0$, there will be a region, $\chi_1 < p \leq 1$, where even H-types will be unwilling to raid and no raiding occurs, while if $\frac{1}{2}B - C(\overline{G},\overline{G}) > 0$, H-types will always be willing to raid even though L-types are not. However, as p decreases L-types will start raiding, as long as they anticipate a net benefit when raiding each other ($\frac{1}{2}B - C(\underline{G},\underline{G}) > 0$).

This demonstrates that disarmament could be an appropriate policy if the H-types were raiding but the L-types were not (i.e., $\chi_2 < p \leq \chi_1$) because lowering the number of H-types in the population will mechanically lower the number of tribes willing to initiate raids. The predatory

[16]It is easy to show $\chi_1 > \chi_2$ when $\frac{1}{2}B - C(\overline{G},\overline{G}) < 0$ and $\frac{1}{2}B - C(\underline{G},\underline{G}) > 0$. See Appendix for proof.

advantage of H-types is eliminated and guns are no longer available to facilitate raids by H-types. However, this policy will simultaneously alter the payoff to initiating a raid for either type, since the probability that either type encounters an L-type will increase and L-types are less costly to fight. That is, the expected net gains to raiding are decreasing in p for both types. In particular, lowering p below the threshold χ_2 will lead to L-types raiding as well as H-types, as the deterrence effect of potentially interacting with a H-type is much weaker.

2.4.2 Deaths and Livestock

The model can also be used to make predictions on the impact of disarmament on other conflict outcomes such as deaths and livestock stolen, using the measure of conflict costs to proxy for deaths and the measure for spoils to proxy for livestock losses.

When only H-types raid the conflict cost of a raid will be determined by the frequency an H-type meets with another H-type (p), the frequency they meet with an L-type $(1-p)$ and the costs associated with these different interactions, which are $2C(\overline{G},\overline{G})$ and $C(\overline{G},\underline{G})+C(\underline{G},\overline{G})$, respectively:

$$p2C(\overline{G},\overline{G})+(1-p)(C(\overline{G},\underline{G})+C(\underline{G},\overline{G}))$$

As p decreases H-types are more likely to meet with L-types, which will led to a decrease in the average cost of a raid, as long as $2C(\overline{G},\overline{G}) > C(\overline{G},\underline{G})+C(\underline{G},\overline{G})$. In addition, as there are fewer H-types to initiate raids, the total conflict cost will also decrease.[17]

Once L-types raid as well as H-types, the average conflict cost of a raid is likely to be lower still, since it is now possible that two L-types will interact, which is less costly than when two H-types interact. In fact, as long as $2C(\overline{G},\overline{G}) > C(\overline{G},\underline{G})+C(\underline{G},\overline{G}) > 2C(\underline{G},\underline{G})$, implying that cross-type interactions are less costly than H-type interactions but more costly than L-type interactions, the average conflict cost of a raid strictly decreases when L-types also raid.[18] Therefore, even though

[17] The total conflict cost when only H-types raid is computed as the average cost of a raid multiplied by frequency of raids (p):

$$p^2 2C(\overline{G},\overline{G})+p(1-p)(C(\overline{G},\underline{G})+C(\underline{G},\overline{G}))$$

and this decreases in p.

[18] See Appendix for proof.

the disarmament may lead to an increase in the frequency of raiding, which will have a direct positive impact on total conflict cost, the average conflict cost per raid is likely to decrease.[19]

Similarly, I can consider the impact of the disarmament on livestock losses. When only H-types raid, the average amount of livestock stolen per raid will increase as p decreases, since the remaining H-types that raid are more likely to meet an L-type and they can obtain more livestock from these tribes. However, the total livestock stolen will decrease as their are fewer H-types to undertake raids.[20]

Once the L-types raid as well as the H-types, there will be a discrete increase in the amount of livestock stolen and then no further changes for decreases in p.[21]

2.4.3 Cross-Border Raids

It is possible to adapt this framework to obtain predictions of the impact of the disarmament policy on cross-border raids as well. For example, since the disarmament campaign did not affect Kenya, Kenyan tribes should become stronger relative to the Ugandans, and their incentive for cross-border raids should increase ceteris paribus. At the same time, the incentive for Ugandans to raid Kenyans

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[19]The total conflict cost when both types raid is computed as the average cost when each type raids multiplied by the frequency each type raids:

$$p^2 2C(\overline{G},\overline{G}) + 2p(1-p)(C(\overline{G},\underline{G}) + C(\underline{G},\overline{G})) + (1-p)^2 2C(\underline{G},\underline{G})$$

and so immediately after L-types start raiding, once p is just less than χ_2, the total conflict cost will discretely increase.

[20]The average livestock obtained when only H-types raid is:

$$p\frac{1}{2}B + (1-p)\frac{\overline{G}}{\overline{G}+\underline{G}}B$$

and this decreases in p, while the total amount taken is:

$$p\left(p\frac{1}{2}B + (1-p)\frac{\overline{G}}{\overline{G}+\underline{G}}B\right)$$

and this increases in p, given that $p \leq 1$.

[21]The average livestock obtained per raid and the total amount taken when both types raid is:

$$p\left(p\frac{1}{2}B + (1-p)\frac{\overline{G}}{\overline{G}+\underline{G}}B\right) + (1-p)\left(p\frac{\underline{G}}{\overline{G}+\underline{G}}B + (1-p)\frac{1}{2}B\right) = \frac{1}{2}B$$

which exceeds the total amount taken when just H-types raid and $p = \chi_2$, but is invariant to further changes in p.

should decrease. Therefore, an additional impact of the disarmament policy could be to increase cross-border raids by Kenyans, while decreasing cross-border raids by Ugandans.

2.4.4 Model Simulation

To illustrate the predictions of the model I simulate the model using the following parameterization:

$$\overline{G} = \gamma \underline{G}$$

$$C(G_1, G_2) = G_2^{\alpha_2} G_1^{-\alpha_1}$$

The parameters are set such that the H-types have twice as many guns as the L-types: $\gamma = 2, \underline{G} = 1$; the elasticity of costs with respect to your own guns is half that of your opponent's guns: $\alpha_1 = 0.5, \alpha_2 = 1$; and I vary the spoils to raiding to show a situation where H-types always raid and a situation when this is not the case: $B = 3$ or 2.5.

Figure 2-5 shows the predicted frequency of livestock raids when either $0 < \chi_2 < \chi_1 < 1$ or $0 < \chi_2 < 1 < \chi_1$ (alternatively, when $B = 2.5$ or 3, respectively). Once p falls below χ_2 there are more raids since both types raid, while the number of raids falls with $p \in (\chi_2, \chi_1]$. There are no raids when $p > \chi_1$, since then even the H-types are not willing to raid.

Figure 2-6 demonstrates that both the total conflict cost and the livestock losses will discretely increase once p falls below χ_2 and both types raid, due to the scale effect of an increase in the volume of raiding, while Figure 2-7 shows the average conflict cost of a raid will decrease during this transition, due to the composition effect of L-types participating in raids.

2.5 Empirical Approach and Results

This section describes the econometric approach employed to assess the impact of the disarmament campaign in Uganda. I start by verifying that the campaign had an impact on the level of firearms in Uganda and whether the military targeted the strongest tribes, which is an assumption of the model. Then I examine the impacts of the campaign on the frequency of livestock raids, the death rate and the livestock theft rate in Uganda. I check whether the costs of raiding decrease by examining the number of deaths caused per raid and whether the campaign caused any cross-border spillovers. Lastly, I estimate the longer term impacts of the campaign.

2.5.1 Impact on Guns

The first part of my analysis examines the impact of the disarmament campaign on the level of firearms in Uganda relative to Kenya. I do this using two measures of firearms that were recorded each week by the field monitors in Uganda and Kenya between 2004 to 2009.[22] Specifically, the field monitors are asked by CEWARN to respond to the following survey questions:[23]

1. Has a disarmament, weapons reduction or buyback program been initiated?

2. Are bullets in use as an exchangeable commodity?

The first question provides direct evidence on the implementation of the policy, while the second question provides more subtle evidence. If the disarmament campaign was implemented, then demand for bullets would decrease, due to the decline in use of firearms and the potential risk of holding bullets, making bullets a less popular tradable commodity. The response to these questions are scored on an index where 0 indicates "disagree", 0.25 indicates "somewhat disagree", 0.50 indicates "neither agree nor disagree", 0.75 indicates "somewhat agree" and 1 indicates "agree".

Figures 2-8 and 2-9 plot the time series of these survey measures for Ugandan and Kenyan field monitors and a vertical red line is used to mark the week the disarmament campaign began. Figure 2-8 suggests that before May 2006 there was no indication of any type of disarmament in either Kenya or Uganda, but after May 2006 field monitors in Uganda recorded a high level of disarmament.[24] Similarly, Figure 2-9 shows that field monitors in Uganda observed a reduction

[22]There are 7 field monitors in Uganda and 5 in Kenya.

[23]The field monitors complete a 55 question survey each week to aid CEWARN in its ability to forecast outbreaks of violence and this survey includes the two question relating to disarmament and bullets.

[24]Immediately after the policy began, field monitors in Kenya also reported an increase in disarmament. However, these reports only stayed high for a few weeks before dropping considerably, suggesting there may have been some misunderstanding by the Kenyan field monitors. In addition, a test on the mean survey response in Kenya before and after May 2006 indicates there was no increase in this survey measure.

in the use of bullets after the policy was implemented, but there was no decrease in Kenya. In addition, Figure 2-10 complements these figures by plotting the total number UPDF disarmament operations recorded each month in the CEWARN incident report data. This figure shows that there was no significant disarmament activity until May 2006 and that after April 2007 the operations had been scaled back considerably.

To test these results formally, Table 2.3 reports the regression results from the following specification:

$$weapons_{dct} = \alpha + \mu_{dc} + \gamma_t + \delta_1 ug_{dc} * disarm_t + \varepsilon_{dct} \tag{2.1}$$

where $weapons_{dct}$ is one of the two survey measures and $ug_{dc} * disarm_t$ is an indicator variable equal to one for all observations in Uganda after May 2006. The field monitor fixed effects, μ_{dc}, control for any permanent differences in the level of firearms in each monitored area, while the week fixed effects, γ_t, non-parametrically control for any region-wide shocks to weapons stocks that may affect both countries. As there are a small number of field monitors, rather than clustering the standard errors by field monitor, a wild cluster boostrap is used to compute p-values for the test $\delta_1 = 0$.

Column (1) of Table 2.3 shows that there was a significant decrease in firearms in Uganda relative to Kenya based on the survey measure of a weapons reduction. Once the disarmament campaign was launched, field monitors in Uganda on average either agreed or somewhat agreed that the a weapons reduction was occurring, while on average Kenyan field monitors continued to somewhat disagree that any such change to firearms was occurring. For the second measure, column (2) shows that the post disarmament response in Ugandan districts decreased by about 0.2 points, indicating that these field monitors on average disagreed that bullets were in use as an exchangeable commodity, while field monitors in Kenya continued to somewhat agree that the opposite was the case in their districts.[25]

[25]Separate regressions are run to test for any differences in the mean survey response in Kenya before and after May 2006 and these results are in shown in Table 1 in the Appendix. These results show that Kenyan field monitors continued to disagree that any weapons reduction was occurring and to agree that bullets were in use as an exchangeable commodity.

2.5.2 Targeting by the Military

The model assumes that the disarmament campaign led to a reduction in p, the proportion of tribes with a high level of arms. This can be checked by examining whether the military were more likely to carry out a disarmament operation on a tribe that had been aggressive in the past. I do this by estimating:

$$\Sigma_{t\in\{0,12\}}UPDF_{it} = \alpha + \mu_i + \delta_1\Sigma_{t\in\{-12,-1\}}raids_{it} + \varepsilon_i \tag{2.2}$$

where $\Sigma_{t\in\{-12,-1\}}raids_{it}$ denotes the number of raids that tribe i initiated in the 12 months before the campaign began, while $\Sigma_{t\in\{0,12\}}UPDF_{it}$ denotes the number of disarmament operations the UPDF carried out in the 12 months after the campaign began on tribe i.[26] I also estimate equation (2.2) using an indicator variable for whether any military visits were experienced, $I[\Sigma_{t\in\{0,12\}}UPDF_{it} > 0]$, as the dependent variable.

Table 2.4 presents the results from estimating equation (2.2). A simple OLS regression, as shown in column (1) and (3), finds that tribes that initiated more raids in the 12 months before the campaign, were more likely to be visited by the military and experienced a larger number of visits. The magnitude of the coefficient estimated in column (1) suggests that about 2.5 raids in the pre-period led to an additional military visit during the campaign. Column (2) verifies the OLS results using a poisson model as an alternative specification, since the number of UPDF visits is a count measure, and corroborates the positive correlation between tribe aggression and military attention.

To summarize the results so far, the disarmament campaign was followed by a reduction in the availability of firearms and ammunition in Uganda but not in Kenya, the disarmament operations were focused in the 12 months after May 2006, and the military paid more attention to disarming the most aggressive tribes during these operations. This verifies the appropriateness of using difference-in-differences to identify the impact of the campaign and that the immediate impacts of the campaign should be observable in the 12 months following the disarmament announcement. In addition, the model assumption that the military targeted the H-types is consistent with the data.

[26] This measure is based on the reports of the military operations recorded in CEWARN's incident reports.

2.5.3 Impact on Conflict

The second stage of the empirical approach estimates how the disarmament campaign affected Ugandan tribes' willingness to participate in violence by comparing the monthly raid rate in Ugandan sublocations to Kenyan sublocations in the 12 months before and after the policy was implemented. To visualize this outcome, Figure 2-11 plots the average monthly raid rate for each country and Figure 2-12 plots the difference in these average rates. These figures reveal converging conflict trends between the two countries prior to the disarmament campaign, with the raid rate decreasing in Uganda while increasing in Kenya, and they suggest that the impact of the policy may have evolved over time. Given this, three different forms of the difference-in-difference model are estimated and for each model the within country differences are also presented.[27]

First, the standard difference-in-difference model is estimated using the following equation:

$$conflict_{ict} = \alpha + \mu_{ic} + \beta_1 ug_{ic} * disarm_t + \beta_2 disarm_t \tag{2.3}$$

$$+\beta_3 ug_{ic} * predisarm_t + \beta_4 predisarm_t + \beta_5 ug_{ic} * postdisarm_t + \beta_6 postdisarm_t + \sum \delta_m D_m + \varepsilon_{ict}$$

where μ_{ic} controls for sublocation fixed effects, $ug_{ic} * disarm_t$ is an indicator for sublocations in Uganda in the 12 months after the disarmament campaign began (starting in May 2006), while $disarm_t$ is an indicator for all sublocations in this period. In addition, the conflict measure is deseasonalized to account for any predictable inter-annual variation in conflict. I do this using a set of month of year dummies (D_m) and the full time series of data (72 months), which is why the additional $predisarm_t$ and $postdisarm_t$ terms have been included.[28]

[27] While most applications of difference-in-difference models show comparable pretrends, allowing for differences in pre-trends in this setting would bias against identifying any effect of the disarmament campaign since in the pre-disarmament period the conflict rate in Kenya is increasing but decreasing in Uganda.

[28] $predisarm_t$ references the period from January 2004 to May 2005 and $postdisarm_t$ references the period from May 2007 to December 2009.

Second, a single time trend for each country is introduced:[29]

$$conflict_{ict} = \alpha + \mu_{ic} + \beta_1 ug_{ic} * disarm_t + \beta_2 disarm_t + \gamma_1 t + \gamma_2 ug_{ic} * t + ... + \sum \delta_m D_m + \varepsilon_{ict} \quad (2.4)$$

Third, a trend break for each country around the disarmament campaign is introduced:

$$conflict_{ict} = \alpha + \mu_{ic} + \beta_1 ug_{ic} * disarm_t + \beta_2 disarm_t + \gamma_1 t + \gamma_2 ug_{ic} * t + \gamma_3 t * disarm_t + ... \quad (2.5)$$

$$... + \gamma_4 ug_{ic} * t * disarm_t + \sum \delta_m D_m + \varepsilon_{ict}$$

Standard errors for all of these equations are clustered to allow for correlation within sublocations.

Before showing the full difference-in-difference results, Table 2.5 first presents the results on changes to the monthly raid rates that occurred within each country. As well as showing the coefficient estimates, the estimated impact of the disarmament 6 months into the post period is included. Reading across columns (1)-(3), the estimates suggest that after the disarmament campaign was introduced the frequency of raids in Ugandan sublocations increased by at least 0.1 raids per month, from a mean raid frequency of 0.27 raids per month, while, under specifications shown in columns (1) and (2), the frequency of raids in Kenyan sublocations did not change from a mean raid frequency of 0.11 raids per month. Under the specification in column (3), the coefficient estimate on $t * disarm_t$ suggests that the number of raids may have slightly decreased in Kenya after the campaign announcement.

The combined difference-in-difference estimates are shown in Table 2.6. Columns (1)-(3) estimate large impacts of the disarmament on the raid frequency in Uganda. The standard difference-in-difference model suggests that the disarmament campaign led to about a 40% increase in the raid frequency in Uganda, while the most flexible model that takes into account the differences in pre-trends between the two countries and allows the impact of the disamament campaign to develop

[29]The conflict measures are deseasonalized for all of the equations, as in (2.3), using corresponding interaction terms for $predisarm_t$ and $postdisarm_t$ with t and $ug_{ic} * t$, although for conciseness the full specifications have not been shown.

over time, provides a much larger and significantly different estimate.[30] This can be understood by noticing that the coefficient on $ug_{ic} * t * disarm_t$ is relatively large, indicating that during the disarmament campaign the monthly raid rate in Uganda increased each month (by about 0.01 raids once pre-trends are accounted for). In the absence of the campaign, the model predicts that the monthly raid rate in Uganda would have decreased each month based on the coefficient estimates on the pre-trend terms t and $ug_{ic} * t$ and the trend reversal that was estimated for Kenya with $t * disarm_t$. Taken together this implies that the impact of the campaign was much larger than the standard difference-in-difference estimate would first suggest. [31] Both estimates indicate that the campaign led to a significant increase in raiding in Uganda.

Table 2.7 examines the impact of the disarmament campaign on the number of deaths that occur as a result of raids in each sublocation, and the impact on resource capture using the number of livestock stolen per sublocation. The results from columns (1)-(3) show that the disarmament campaign did not lead to an increase in the monthly death rate in Uganda, even though the number of raids increased. This suggests that raids became less deadly, which is in line with the model prediction that an increase in raids can be explained by participation of weaker tribes who are less costly to fight and will reduce the average cost of a raid. Columns (5)-(6) indicate that the disarmament campaign led to an increase in the total volume of livestock stolen, which is also predicted by the model when both types raid due to the scale effect of more raids occurring.

In addition, Table 2.8 directly estimates whether the number of deaths that occurred per raid decreased, given that the model predicted that this would result if the increase in raiding was due to participation of weaker tribes. Columns (1)-(3) corroborate the findings from Table 2.7 and directly show that raids became less deadly, while columns (4)-(6) show that the number of livestock taken per raid did not significantly change. This latter result could also be consistent with the model, as the model predicts only a small decrease in the number of livestock taken per raid when both types

[30]The row labelled "Difference between estimates" indicates whether the difference between the estimates from specifications (2) and (3) relative to specification (1) is significant.

[31]The difference-in-difference estimate for equation (2.5) is computed for the impact 6 months into the post period: $\hat{\beta}_1 + 6\hat{\gamma}_4$, as t=0 when $disarm_t$ first becomes 1.

raid that scales with the relative arms levels of the different types.[32]

Together these results suggest that the disarmament had the the unintended effect of increasing the number of raids. While reducing the guns of heavily armed tribes may have eliminated their predatory advantage, this appears to have led to weaker tribes choosing to raid that had previously been deterred. This increase in raiding was accompanied by a decrease in the average cost of a raid, consistent with the hypothesis that weaker tribes had started to raid, and overall this led to no change to the monthly death rate in Uganda.

Heterogeneous Impacts on Conflict

A secondary consideration is whether the disarmament campaign impacted the propensity to raid among stronger tribes, and whether the campaign impacted the vulnerability of different sublocations to raids. To investigate such heterogenous impacts, I estimate:

$$\Delta raids_i = \alpha + \mu_i + \beta_1 \Sigma_{t\in\{-12,-1\}} raids_{it} + \varepsilon_i \tag{2.6}$$

where $\Sigma_{t\in\{-12,-1\}} raids_{it}$ denotes the number of raids that tribe i initiated in the 12 months before the campaign began, or that occurred in sublocation i in the pre-campaign period, while $\Delta raids_i$ denotes the corresponding change in the number of raids between the 12 months before and after the campaign.

The results in column (1) of Table 2.9 suggest a negative correlation between the pre-period level of aggression of tribes and the impact of the campaign. That is, tribes that were less aggressive before the campaign contributed more to the to the increase in raids, while tribes that were more aggressive contributed less. While this result is imprecisely estimated, it is consistent with the disarmament campaign being effective at weakening stronger tribes and changing the incentives of weaker tribes.

[32]The relative decrease in number of livestock taken per raid is predicted to be

$$\frac{1}{2}p_0 + (1-p_0)\frac{\overline{G}}{\overline{G}+\underline{G}} - \frac{1}{2} \in \left[0, \frac{\overline{G}}{\overline{G}+\underline{G}}\right]$$

where p_0 is the initial proportion of H-types. See Appendix for details.

The results in column (2) suggest that sublocations that were less vulnerable before the campaign, experienced the largest increase in raids. Under the assumption that the strongest tribes tended to live in the least vulnerable sublocations, these results are also consistent with the disarmament campaign being effective at weakening stronger tribes and changing the incentives of weaker tribes.

Descriptive evidence is also provided in Figure 2-13 which shows the change in the number of raids by the total number of raids in the pre-campaign period for each sublocation and tribe, and visually demonstrates the negative correlation between post-campaign aggression and vulnerability with pre-campaign aggression and vulnerability.

2.5.4 Impact on Cross-border Raids

The primary sample for the difference-in-difference equations excluded Kenyan sublocations within 20 km from the Kenya-Uganda border in case the disarmament policy led to a decrease in the number of raids in these sublocations only because of a decrease in raids by Ugandans on Kenyans. The next stage to the empirical approach directly estimates whether any such spillovers occurred using sublocations within 20 km of the border in each country. For each country, I estimate:[33]

$$conflict_{ict} = \alpha + \mu_{ic} + \beta_1 disarm_t + \varepsilon_{ict} \tag{2.7}$$

In addition to estimating (2.7) for each country, separate equations are estimated for each type of initiator-target interactions: Ugandans attacking Ugandans, Ugandans attacking Kenyans, Kenyans attacking Kenyans and Kenyans attacking Ugandans. Thus, any change in conflict activity near the border is decomposed into the change contributed by each interaction to address whether the policy may have led to an increased vulnerability of Ugandans to Kenyans or even displacement effects within Kenya.[34]

[33] The conflict measures are again deseasonalized, as in (2.3), using a set of month of year dummies (D_m) and the full time series of data (72 months).

[34] Only (2.7) is estimated for each country and each initiator-target interaction and no equivalent difference-in-difference regression is estimated, since there is no obvious comparison group for these border categories.

Figure 2-14 plots the time series on raids for each country, showing separately this outcome for cross-border interactions (for example, Kenyans attacking Ugandans or Ugandans attacking Kenyans) and within country interactions (for example, Ugandans attacking Ugandans or Kenyans attacking Kenyans). The figure suggests that in the Ugandan border sublocations there was only an increase in the raiding between Ugandans, while in the Kenyan border sublocations there was both a decrease in raids initiated by Ugandans as well as other Kenyans.

Table 2.10 provides the corresponding regression analysis for the Ugandan sublocations. In these regressions, only a difference in the level of raiding is evaluated as the time series plots do not suggest there were any pre-trends or trend changes after the policy was implemented. Column (1) of Table 2.10 shows that raiding significantly increased in the Ugandan border sublocations. Moreover, the results in columns (2) and (3) verify what was seen in Figure 2-14, showing that this increase was largely due to an increase in the raids between Ugandans, not by cross-border raids from Kenyans. Columns (4)-(6) show that there was no change to the monthly death rate, but columns (7)-(9) show an increase to the livestock theft rate in Uganda border sublocations that was driven by an increase in Ugandan-on-Ugandan conflict. The model implied that the Ugandans should have become a more attractive target for Kenyans, so given that there was no increase in this type of cross-border raid, this indicates there may have been other factors that limited the ability of Kenyan tribes to carry out cross-border raids.[35]

Table 2.11 presents the same analysis but for Kenyan sublocations near to the Kenya-Uganda border. This shows an overall decrease in raiding in these sublocations that is almost equally due to a decrease in Kenyan-on-Kenyan raids and Ugandan-on-Kenyan raids. This indicates that the campaign made Kenyans less vulnerable to Ugandan attacks, even though it did not make Ugandans more vulnerable to Kenyans. The disarmament may have also contributed to lowering violence between Kenyans, for example, if the decrease in attacks from Ugandans lowered the necessity for Kenyans to raid each other.[36] Columns (4)-(9) show that this change in the raid frequency did

[35]For example, the increase in military presence due to the disarmament campaign may have had a stronger deterrent affect on Kenyan tribes than Ugandan tribes.

[36]Alternatively, if bullets or weapons became more widely available in the border region of Kenya due to the disarmament campaign, this may have had a negative impact on raids in Kenya as raiding may have been perceived to be more costly by Kenyans. Appendix table 2 investigates this relationship but finds no indication that an increase in the

not, however, lead to a lower the monthly death rate or livestock theft rate in the Kenyan border sublocations.

2.5.5 Longer Term Impacts on Conflict

The last stage of the empirical approach investigates the longevity of the impact of the campaign. Figure 2-10 demonstrated that the disarmament operations were focused in the 12 months between May 2006 - April 2007 so the last series of regressions examine whether the impact of the campaign on the raid frequency extended into the following 12 months. Specifically, the frequency of livestock raids between May 2006 - April 2008 is compared to May 2005 - April 2006 using corresponding specifications to (2.3) - (2.5). For example, the corresponding regression to (2.3) is:

$$conflict_{ict} = \alpha + \mu_{ic} + \beta_1 ug_{ic} * LTdisarm_t + \beta_2 LTdisarm_t + \beta_3 ug_{ic} * predisarm_t + \beta_4 predisarm_t \tag{2.8}$$
$$+\beta_5 ug_{ic} * postpostdisarm_t + \beta_6 postpostdisarm_t + \sum \delta_m D_m + \varepsilon_{ict}$$

where $LTdisarm_t$ is an indicator variable for the 24 month period May 2006 - April 2008. The terms $predisarm_t$ and $postpostdisarm_t$ correspond to the periods January 2004 - April 2005 and May 2008 - December 2009, and are included to enable the deseasonalization of the conflict measure, as in (2.3) - (2.5), using month of year dummies (D_m) and the full time series of data.

By comparing the results in Table 2.12, where the longer term impact estimates are shown, to the results in Tables 2.5 and 2.6, where the initial impact estimates are shown, we can see that the impact of the disarmament continued into the 12 months immediately after the cordon and search operations had halted. To test whether there was any fade-out of the impact of the campaign on the raid frequency in this period, I include a separate indicator variable, denoted $postdisarm_t$, for the months May 2007 - April 2008. These results are in Table 2.13 and a comparison of the difference-in-difference estimates evaluated at 6 months and 18 months after the campaign announcement

availability of bullets or weapons led to the lower raid rate.

is shown in the third panel.[37] The least flexible difference-in-difference estimate, that is shown in column (1), indicates that there was fade out, while the more flexible specifications, that are shown in columns (2) and (3) find no such fade out. This difference can be explained by noticing that the coefficients on the post trend terms ($LTdisarm_t * t$) for both Uganda and Kenya are large in magnitude and of opposite signs, and prevail throughout the 24 months after the announcement. Therefore, increasing the flexibility of the specification to allow for trend changes leads to estimates that suggest that the impact of the campaign was sustained throughout the 24 months after the campaign announcement.

To check whether the disarmament campaign impacted the propensity to raid among stronger tribes or the vulnerability of different sublocations to raids over this extended time period, Figure 2-15 plots the number of raids 12-24 months after the campaign against the number of raids 0-12 months before the campaign by sublocation and tribe. This figure indicates that while a couple of sublocations became much less vulnerable to raids and a few tribes became less aggressive, by this point in time there was not a substantial change to vulnerability of sublocations or the strength of tribes, relative to their pre-disarmament ranking, suggesting that the campaign did not affect the distribution of power in the long run. Therefore, while the impact of the campaign on the raid frequency continued after the campaign was halted, these figures suggest that overall the distribution of power was not permanently affected by the campaign.

2.5.6 Robustness Checks

The regression results from Table 2.6 undergo robustness checks that involve extending the analysis to include the 20 months before and after the campaign announcement, removing observations for months in which a forceful UPDF disarmament operation was reported in the sublocation and removing sublocations in Uganda that were within 20 km of the Uganda-Kenya border. The first check extends the period of analysis to include months in which an additional 9 operations occurred so that in total the period of analysis covers 89 out of 93 recorded operations. The second check is

[37] The initial difference-in-difference estimates in Tables 2.5 and 2.6 evaluated the impact of the campaign 6 months after its announcement.

to verify that the mechanism through which the campaign led to an increase in raids was not due to the military incapacitating tribes and preventing them from responding to attacks. The third check is to verify that the increase in raids in Uganda was not due to an increase in attacks from Kenyans. These checks are shown in Table 3 in the appendix and the results are robust to all three checks, although the precision of the estimates decrease once the sample size is reduced by the third check.

Another potential concern regarding this analysis is whether the effort of field monitors varied systematically with the timing of the disarmament campaign and across the two countries. For example, if field monitors felt greater motivation to record raid incidents while the disarmament campaign was implemented, this could lead to an overestimate of its impact, particularly if this increased effort was only exerted by field monitors in Uganda. To address this concern I examine the recording of two other types of crime between May 2005 - April 2007: banditry and assault. Most incidents of banditry involve a hold-up of travellers (traders or aid workers) by tribesmen, while assaults mainly involve drunken brawls and violent quarrels. As banditry involves aggression by tribes to people from outside the region, the incentive to carry out such hold-ups should decrease if the disarmament is effective at removing weapons from the tribes and the tribes used guns to carry out hold-ups. In contrast, as assaults tend to occur between tribesmen and not to outsiders, the willingness to assault each other should increase when gun carrying decreases if the tribesmen care about the risks of violent altercations. The results shown in Table 4 in the appendix are in line with these predictions and are consistent with the assumption that the field monitors were not more likely to record incidents during the disarmament campaign.

2.6 Conclusion

The motivation for this study was to understand how guns influence violent conflict and to understand the effectiveness of the UPDF's disarmament campaign in the highly volatile region of the Ugandan Karamoja. Some of the questions that I hoped to address were: do guns facilitate violence by enabling some tribes to become significantly stronger than other tribes, and therefore, would the campaign be able to reduce livestock raiding by levelling the playing field? Or, would it worsen the situation by lowering the costs of conflict for all tribes, and encourage greater participation in livestock raiding?

My most substantial finding was that after the disarmament campaign the frequency of livestock raids (my measure of violent conflict) increased in Uganda by at least 40%, while there was no increase to the frequency of livestock raids in Kenyan. Moreover, even at the Kenya-Uganda border, the increase in livestock raids in Uganda was driven by an increase in Ugandan initiated raids on other Ugandans, rather than an increase in Kenyan initiated raids on Ugandans, demonstrating that the finding was not due to any spillover effect the campaign might have had on Kenya. This suggests that guns were important for deterrence among Ugandan tribes, and the disarmament had the unfortunate impact of increasing the number of livestock raids carried out each month in Ugandan sublocations from 0.27 to over 0.38. There was no impact on the monthly death rate which remained at approximately 0.4 deaths per sublocation per month, suggesting that the campaign had no effect on reducing the overall costs to human life. However, the number of deaths per raid decreased by about 80-120% showing us that the campaign did lead to raids becoming less deadly. There is also no evidence that aggregate amount of resource capture was reduced after the campaign, because even though the number of livestock stolen per raid may have fallen, the total livestock stolen per month from Ugandan sublocations increased due to the increased number of raids.

The disarmament campaign in the Ugandan Karamoja demonstrates that in an insecure environment guns may function both as a tool for protection, by increasing the costs of conflict and deterring raids, as well as a tool for aggression. Clearly firearms in the region have contributed to its insecurity, but the forceful removal of weapons led to greater instability, rather than lowering the frequency of violent conflicts, or the homocide rates. Despite the strong military involvement in this campaign, the military ultimately had limited ability to provide protection from these violent conflicts or create a direct form of deterrence, highlighting the difficulty in containing and addressing violence in these environments. Another implication of this resarch is that the tribes had an unusually high willingness to participate in conflict suggesting that an alternative intervention would be to decrease the benefits or demand for raiding. This could be achieved by either improving the tribes' standard of living, to reduce the marginal benefits to raiding, or by introducing livestock branding scheme, to reduce the amount of stolen livestock that attackers could be retain. Perhaps the greatest obstacles of this particular intervention were the inability of state actors to control the flow of illegal arms into the region, preventing a complete removal of guns, or to provide appropriate protection to disarmed tribes. In conclusion, this example demonstrates that a one-dimensional approach of reducing firearms can be more detrimental than effective at addressing violent conflict, particularly in this type of insecure environment.

2.7 Tables

Table 2.1: Selected Human Development Indicators

	Uganda National	Uganda Karamoja	Kenya National	Kenya Karamoja
Life Expectancy (1)	50.4 yrs	47.7 yrs	52.0 yrs	46.9 yrs
Population living below poverty line (2)	31%	82%	58%	74%
Maternal mortality rate (per 100,000 live births) (3)	435	750	414	.
Infant mortality rate (per 1,000 live births) (4)	76	105	55	.
Under 5 mortality rate (per 1,000 live births) (4)	134	174	84	.
Global Acute Malnutrition (GAM) rate (5)	6%	11%	5%	15%
Access to sanitation units (4)	62%	9%	31%	32%
Access to safe water (4)	63%	40%	59%	52%
Literacy rate (3)	67%	11%	73%	.
Population Projection (6)		1,062,300		502,000

Sources: 1.UNDP 2007; 2. World Bank 2006; 3. UDHS 2006; 4. UNICEF/WHO 2008; 5. MoH/WFP April 2009; 6. UBOS 2009, GoK 2008.

Table 2.2: Selected Conflict and Pastoral Indicators

	Uganda Karamoja	Kenya Karamoja	Both
Population (1)	1,062,300	502,000	1,564,300
Total Cattle (1)	1,472,925	234,420	1,707,345
Total livestock (1)	2,846,601	3,631,530	6,478,131
Average Household Size (1)	6.2	6.3	6.2
Livestock Raids (per month per subloc) (2)	0.31	0.09	0.20
% Livestock Raids that are Ug-Ug or Ke-Ke (2)	*89%*	*82%*	
% Livestock Raids that are Ke-Ug or Ug-Ke (2)	*11%*	*18%*	
Deaths (per month per subloc) (2)	0.57	0.12	0.48
Livestock stolen (per month per subloc) (2)	24.9	11.3	22.2
Pastoral conflict death rate (per 100,000) (2)	55	17	42
Firearms deaths Colombia (per 100,000) (3)			*60*
Firearms deaths US (per 100,000) (3)			*4*
Livestock theft rate (per 100,000) (2)	1000	500	700

Sources: 1. [UBOS 2009, GoK 2008], 2. [CEWARN Jan 2004-May 2006], 3. [Small Arms Survey 2006]

Table 2.3: Weekly Survey Reports on Disarmament Measures

	Weapons Reduce	Bullet Commodity
$uganda_{ic} * disarm_t$	0.54	-0.26
p-value for test: $\delta_1 = 0$	(0.04)**	(0.06)*
N	1,040	1,040
Pre-disarmament mean in Uganda	0.12	0.28
Pre-disarmament mean in Kenya	0.22	0.70

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $uganda_{ic} * disarm_t$ is an indicator variable for observations in Uganda after May 2006. These regressions include controls for field monitor fixed effects and week fixed effects. The pre-disarmament means give the mean level of each survey measure in Uganda and Kenya before the disarmament campaign. The survey measures record each field monitors response to the questions: (1) Has a disarmament, weapons reduction or buyback program been initiated? (2) Are bullets in use as an exchangeable commodity? 0 indicates disagreement and 1 indicates agreement. A wild cluster bootstrap is used to compute p-values for the test that coefficient of interest ($uganda_{ic} * disarm_t$) is zero. These p-values are reported in parenthesis and the bootstrap is clustered at the level the survey measures are collected.

Table 2.4: Evidence of Disarmament attention to Stronger Tribes

	Total # of UPDF visits		Any UPDF visits (0/1)
	OLS	Poisson	OLS
	(1)	(2)	(3)
$\Sigma raids_{i,t-1}$	0.382	0.048	0.013
	[0.170]*	[0.007]***	[0.007]
R^2	0.46		0.37
N	8	8	8

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: The outcome variable "UPDF visits" is obtained by using records on the disarmament operations that are recorded in the incident reports. $\Sigma raids_{i,t-1}$ denotes the number of raids that a tribe initiated in the 12 months before the disarmament campaign. Being visited by the UPDF during the disarmament is perfectly predicted when a tribe initiates a raid at least 6 times in the pre-disarmament period.

Table 2.5: First Difference Estimates - Raids (Sublocation by Month)

	(1)	(2)	(3)
		Ugandan sublocations	
$disarm_t$	0.11	0.12	0.16
	[0.04]**	[0.08]	[0.09]*
t		-0.00	-0.02
		[0.01]	[0.01]
$disarm_t * t$			0.03
			[0.01]**
Estimated effect at t=6 months	0.11	0.12	0.34
	[0.04]**	[0.08]	[0.14]**
Pre-disarmament mean in Uganda	0.27	0.27	0.27
R^2	0.02	0.02	0.03
N	4,108	4,108	4,108
		Kenyan sublocations	
$disarm_t$	-0.01	-0.03	-0.05
	[0.02]	[0.04]	[0.04]
t		0.00	0.01
		[0.00]	[0.00]**
$disarm_t * t$			-0.01
			[0.01]**
Estimated effect at t=6 months	-0.01	-0.03	-0.13
	[0.02]	[0.04]	[0.05]*
Pre-disarmament mean in Kenya	0.11	0.11	0.11
R^2	0.01	0.01	0.02
N	3,713	3,713	3,713

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which raids are reported, and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. The fourth row of each panel shows the estimated impact of the disarmament 6 months into the post period. Month fixed effects and the full time series are used to deseasonalize the data.

Table 2.6: Difference-in-Difference Estimates - Monthly Raid Rate

	(1)	(2)	(3)
$disarm_t$	-0.01	-0.01	-0.02
	[0.02]	[0.04]	[0.04]
$uganda_{ic} * disarm_t$	0.12	0.11	0.15
	[0.05]**	[0.08]	[0.08]*
t		0.00	0.01
		[0.00]	[0.00]
$uganda_{ic} * t$		0.00	-0.02
		[0.01]	[0.01]**
$disarm_t * t$			-0.01
			[0.01]**
$uganda_{ic} * disarm_t * t$			0.04
			[0.01]***
Estimated effect at t=6 months	0.12	0.11	0.41
	[0.05]**	[0.08]	[0.13]**
Difference between estimates	.	.	**
Pre-disarmament mean in Uganda	0.27	0.27	0.27
R^2	0.01	0.02	0.02
N	7,821	7,821	7,821

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, $uganda_{ic}$ is an indicator variable for observations in Uganda, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. The row labelled "Estimated effect at t=6 months" shows the estimated impact of the disarmament 6 months into the post period in Uganda relative to Kenya. The row labelled "Difference between estimates" indicates whether the difference between the estimates from specifications (2) and (3) relative to specification (1) is significant. The reported "pre-disarmament mean in Uganda" is mean raid rate in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

Table 2.7: Difference-in-Difference Estimates - All Conflict Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Monthly Death Rate			Monthly Livestock Thefts		
$disarm_t$	0.02	0.17	0.20	8.9	-29.1	-33.8
	[0.06]	[0.24]	[0.25]	[8.6]	[28.9]	[30.9]
$uganda_{ic} * disarm_t$	0.03	-0.08	-0.12	-0.3	65.8	71.4
	[0.12]	[0.27]	[0.27]	[10.4]	[31.7]**	[33.2]**
t		-0.01	-0.03		3.1	5.4
		[0.02]	[0.02]		[2.3]	[3.5]
$uganda_{ic} * t$		0.01	0.03		-5.3	-8.4
		[0.02]	[0.03]		[2.6]**	[3.7]**
$disarm_t * t$			0.03			-4.1
			[0.01]**			[2.6]
$uganda_{ic} * disarm_t * t$			-0.04			5.6
			[0.03]			[2.9]*
Estimated effect at t=6 months	0.03	-0.08	-0.36	-0.3	65.8	105.0
	[0.12]	[0.27]	[0.37]	[10.4]	[31.7]**	[45.3]**
Pre-disarmament mean in Uganda	0.38	0.38	0.38	17.7	17.7	17.7
Difference between estimates	.	.	.	.	**	**
R^2	0.00	0.00	0.00	0.01	0.01	0.01
N	7,821	7,821	7,821	7,821	7,821	7,821

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, $uganda_{ic}$ is an indicator variable for observations in Uganda, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. The row labelled "Estimated effect at t=6 months" shows the estimated impact of the disarmament 6 months into the post period in Uganda relative to Kenya. The row labelled "Difference between estimates" indicates whether the difference between the estimates from specifications (2) and (3) relative to specification (1) is significant. The reported "pre-disarmament mean in Uganda" is mean death or livestock theft rate in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

Table 2.8: Difference-in-Difference Estimates - Outcomes per Raid

	(1)	(2)	(3)	(4)	(5)	(6)
		Deaths per Raid			Livestock per Raid	
$disarm_t$	0.87	2.19	1.83	127.1	69.7	37.3
	[0.92]	[2.26]	[2.19]	[127.9]	[87.6]	[74.1]
$uganda_{ic} * disarm_t$	-1.55	-1.08	-1.02	-115.3	16.2	45.3
	[1.12]	[1.29]	[1.22]	[129.6]	[94.7]	[80.9]
t		-0.11	-0.33		5.2	-16.9
		[0.17]	[0.20]		[12.5]	[14.4]
$uganda_{ic} * t$		-0.03	0.29		-10.9	12.6
		[0.10]	[0.11]***		[12.9]	[14.7]
$disarm_t * t$			0.49			49.5
			[0.21]**			[28.2]*
$uganda_{ic} * disarm_t * t$			-0.66			-52.2
			[0.23]***			[28.3]*
Estimated effect at t=6 months	-1.55	-1.08	-4.98	-115.3	16.2	-267.6
	[1.12]	[1.29]	[1.85]***	[129.6]	[94.7]	[195.8]
Pre-disarmament mean in Uganda	1.56	1.56	1.56	54.0	54.0	54.0
Difference between estimates	.	.	***	.	.	.
R^2	0.01	0.02	0.02	0.01	0.03	0.04
N	1,208	1,208	1,208	1,208	1,208	1,208

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, $uganda_{ic}$ is an indicator variable for observations in Uganda, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample for each country includes all sublocations (to increase the sample size). The row labelled "Estimated effect at t=6 months" shows the estimated impact of the disarmament 6 months into the post period in Uganda relative to Kenya. The row labelled "Difference between estimates" indicates whether the difference between the estimates from specifications (2) and (3) relative to specification (1) is significant. The reported "pre-disarmament mean in Uganda" is mean deaths or livestock taken per raid in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

Table 2.9: Disarmament Impact by Pre-Raid Vulnerability and Strength

	$\Delta raids_i$	
	by tribe	by sublocation
$\Sigma raids_{i,t-1}$	-0.33	-0.33
	[0.35]	[0.12]***
R^2	0.13	0.13
N	8	56

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $\Delta raids_i$ denotes the change in number of raids between the 12 months before and after the campaign began and $\Sigma raids_{i,t-1}$ denotes the number of raids that a tribe initiated in the 12 months before the disarmament campaign, or the number of raids that occurred in a sublocation in the 12 months before the disarmament campaign.

Table 2.10: First Difference Estimates for Border Sublocations in Uganda - All Conflict Outcomes

	Raids			Deaths			Livestock		
	All	Ug-Ug	Ke-Ug	All	Ug-Ug	Ke-Ug	All	Ug-Ug	Ke-Ug
$disarm_t$	0.14	0.13	0.01	-0.08	-0.04	-0.04	17.8	17.4	0.3
	[0.06]**	[0.06]**	[0.02]	[0.15]	[0.15]	[0.06]	[8.3]**	[8.3]**	[0.9]
Pre-disarmament mean	0.20	0.15	0.05	0.20	0.13	0.07	4.6	2.4	2.2
R^2	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01
N	2,212	2,212	2,212	2,212	2,212	2,212	2,212	2,212	2,212

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement. The regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample includeds only sublocations that have centres within 20km of the Uganda-Kenya border. The results are broken down into the change in conflict frequency caused by both within country raids (Ug-Ug) and cross border raids from Kenyans attacking Ugandans (Ke-Ug). Month fixed effects and the full time series are used to deseasonalize the data. The reported "pre-disarmament mean" is used to denote the mean conflict measure in the 12 months before the campaign was announced.

Table 2.11: First Difference Estimates for Border Sublocations in Kenya - All Conflict Outcomes

	Raids			Deaths			Livestock		
	All	Ke-Ke	Ug-Ke	All	Ke-Ke	Ug-Ke	All	Ke-Ke	Ug-Ke
$disarm_t$	-0.10	-0.06	-0.04	-0.01	0.01	-0.02	6.8	11.3	-4.4
	[0.03]***	[0.02]**	[0.02]**	[0.05]	[0.05]	[0.02]	[10.7]	[10.1]	[2.8]
Pre-disarmament mean	0.18	0.11	0.07	0.04	-0.00	0.04	4.8	-3.9	8.7
R^2	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
N	1,896	1,896	1,896	1,896	1,896	1,896	1,896	1,896	1,896

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement. The regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample includeds only sublocations that have centres within 20km of the Uganda-Kenya border. The results are broken down into the change in conflict frequency caused by both within country raids (Ke-Ke) and cross border raids from Ugandans attacking Kenyans (Ug-Ke). Month fixed effects and the full time series are used to deseasonalize the data. The reported "pre-disarmament mean" is used to denote the mean conflict measure in the 12 months before the campaign was announced.

Table 2.12: Cumulative Long Term Impacts - Raids (Sublocation by Month)

	(1)	(2)	(3)
		Ugandan sublocations	
$LTdisarm_t$	0.07	0.18	0.27
	[0.04]*	[0.06]***	[0.08]***
t		-0.01	-0.02
		[0.00]**	[0.01]*
$LTdisarm_t * t$			0.02
			[0.01]
Estimated effect at t=18 months	0.07	0.18	0.59
	[0.04]*	[0.06]**	[0.27]**
R^2	0.02	0.03	0.03
N	4,108	4,108	4,108
		Kenyan sublocations	
$LTdisarm_t$	-0.01	0.00	-0.06
	[0.02]	[0.03]	[0.03]*
t		-0.00	0.01
		[0.00]	[0.00]**
$LTdisarm_t * t$			-0.01
			[0.00]**
Estimated effect at t=18 months	-0.01	0.00	-0.27
	[0.02]	[0.03]	[0.11]**
R^2	0.01	0.02	0.02
N	3,713	3,713	3,713
		All sublocations	
Estimated effect at t=18 months	0.08	0.15	0.64
	[0.04]*	[0.05]***	[0.27]**
Difference between estimates	.	.	**
Pre-disarmament mean in Uganda	0.27	0.27	0.27
R^2	0.02	0.02	0.02
N	7,821	7,821	7,821

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $LTdisarm_t$ is an indicator variable for observations between May 2006 - April 2008, the 24 months following the campaign announcement, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. The estimated impact of the disarmament 18 months into the post period in Uganda relative to Kenya is shown in the third panel. The row labelled "Difference between estimates" indicates whether the difference between these estimates from specifications (2) and (3) relative to specification (1) is significant. The reported "pre-disarmament mean in Uganda" is mean deaths or livestock taken per raid in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

Table 2.13: Decomposition of Cumulative Long Term Impacts- Raids (Sublocation by Month)

	(1)	(2)	(3)
		Ugandan sublocations	
$LTdisarm_t$	0.11	0.16	0.18
	[0.04]**	[0.07]**	[0.09]**
$postdisarm_t$	-0.08	-0.03	-0.10
	[0.04]**	[0.08]	[0.08]
t		-0.00	-0.02
		[0.00]	[0.01]
$LTdisarm_t * t$			0.03
			[0.01]**
$postdisarm_t * t$			-0.02
			[0.01]
		Kenyan sublocations	
$LTdisarm_t$	-0.01	0.00	-0.04
	[0.02]	[0.04]	[0.04]
$postdisarm_t$	-0.01	-0.00	0.05
	[0.02]	[0.04]	[0.05]
t		0.00	0.01
		[0.00]	[0.00]**
$LTdisarm_t * t$			-0.01
			[0.01]**
$postdisarm_t * t$			0.00
			[0.00]
		All sublocations	
Estimated effect at t=6 months	0.12	0.11	0.41
	[0.05]**	[0.06]*	[0.13]**
Estimated effect at t=18 months	0.05	0.03	0.61
	[0.04]	[0.13]	[0.27]*
Difference b/w estimates?	x		
Pre-disarmament mean in Uganda	0.27	0.27	0.27
R^2	0.02	0.02	0.02
N	7,821	7,821	7,821

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $LTdisarm_t$ is an indicator variable for the period May 2006 - April 2008, the 24 months following the campaign announcement, while $postdisarm_t$ denotes the second half of this period, May 2007 - April 2008, and t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. The estimated impact of the disarmament at both 6 and 18 months into the post period in Uganda relative to Kenya is shown in the third panel. The row labelled "Difference b/w estimates?" indicates whether the difference between these two estimates from each specification is significant. The reported "pre-disarmament mean in Uganda" is mean raid rate in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

2.8 Figures

Figure 2-1: The Karamoja Region

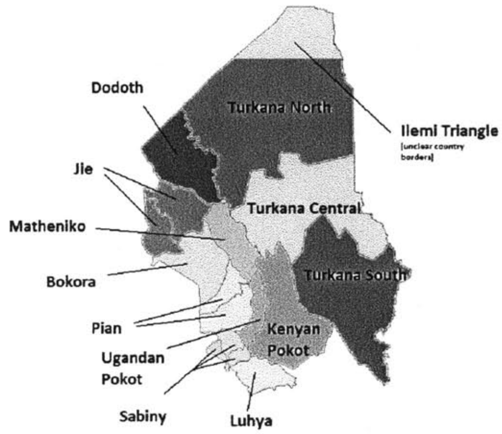


Figure 2-2: The Karamoja Tribes. (Sources include Mkutu (2006) and various NGO reports.)

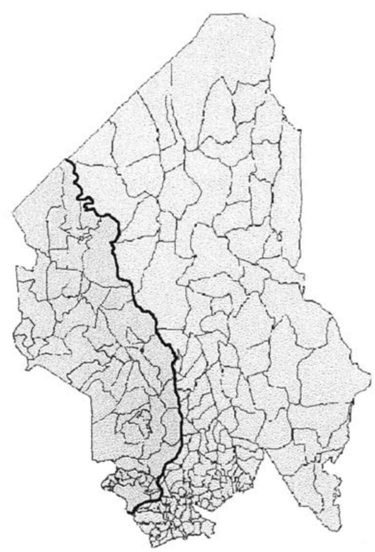


Figure 2-3: The 51 Ugandan and 61 Kenyan sublocations

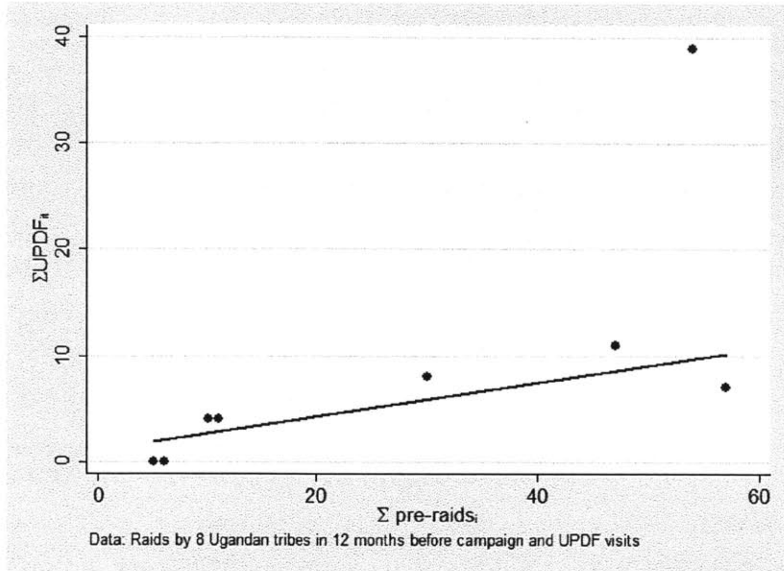
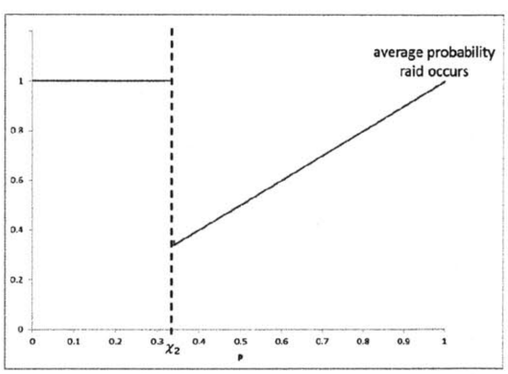
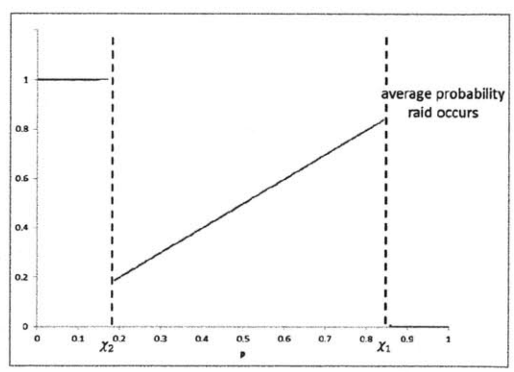


Figure 2-4: UPDF visits and pre-campaign raids by tribe

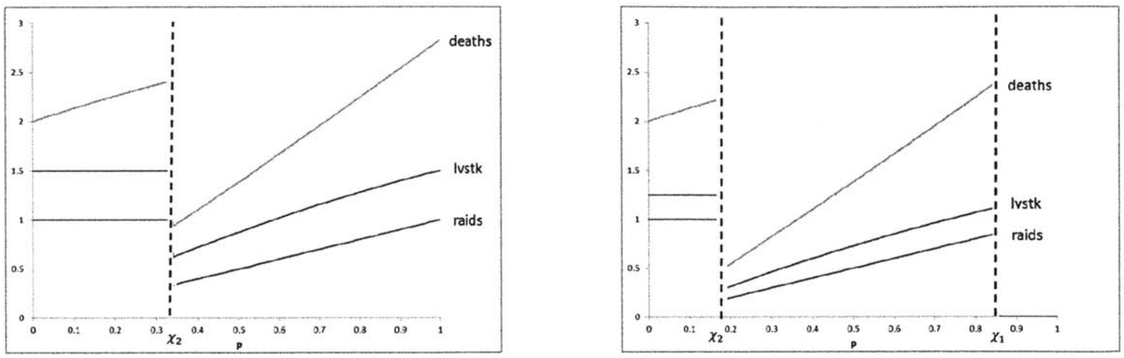


(a) $0 < \chi_2 < 1 < \chi_1$



(b) $0 < \chi_2 < \chi_1 < 1$

Figure 2-5: Number of raids initiated



(a) $0 < \chi_2 < 1 < \chi_1$

(b) $0 < \chi_2 < \chi_1 < 1$

Figure 2-6: Total conflict cost and livestock losses

(a) $0 < \chi_2 < 1 < \chi_1$

(b) $0 < \chi_2 < \chi_1 < 1$

Figure 2-7: Average conflict cost and livestock stolen per raid

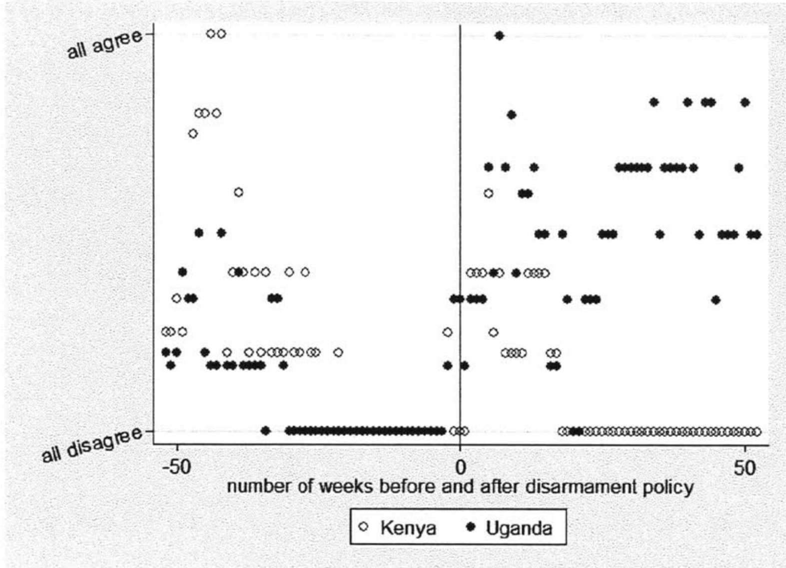


Figure 2-8: Survey Reports on a Weapons Reduction or Disarmament

Note: Time series plot of the average weekly field monitor scores in Uganda (solid points) and Kenya (circles) to the survey question: Has a disarmament, weapons reduction or buyback been initiated? There are 5 field monitors in Kenya and 4 in Uganda.

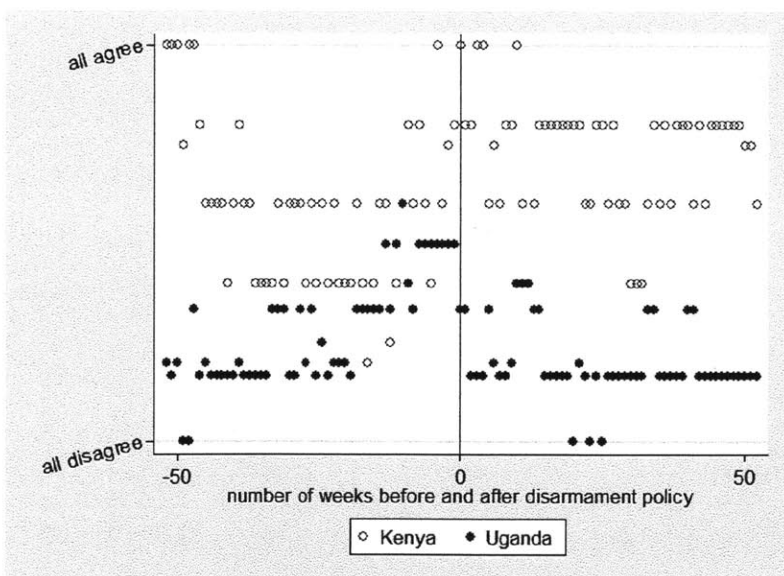


Figure 2-9: Survey Reports on the use of Bullets as an Exchangeable Commodity

Note: Time series plot of the average weekly field monitor scores in Uganda (solid points) and Kenya (circles) to the survey question: Are bullets in use as an exchangeable commodity? There are 5 field monitors in Kenya and 4 in Uganda.

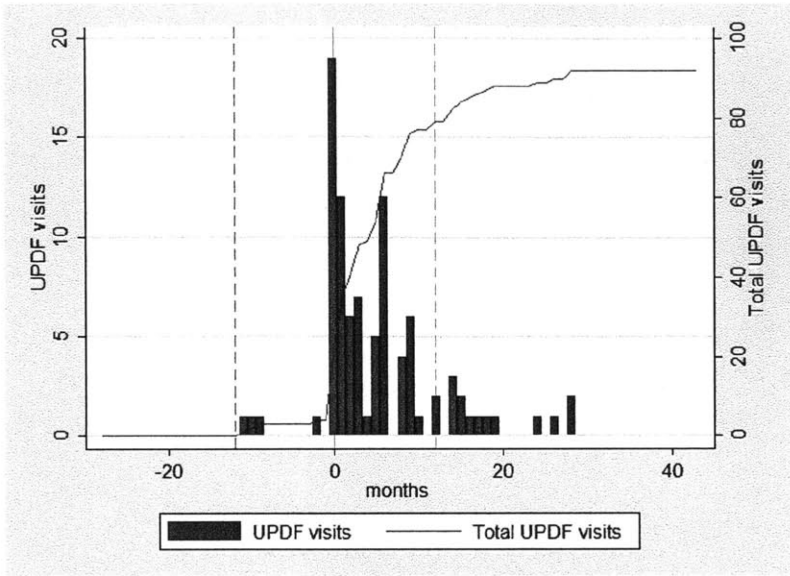


Figure 2-10: Raids and UPDF Operations in Uganda

Note: Time series plot of the total number of raids in Uganda and the number of reported forceful UPDF disarmament operations. The solid red line at month 0 denotes May 2006, while the dashed red lines show the 12 month cut-offs before and after this date.

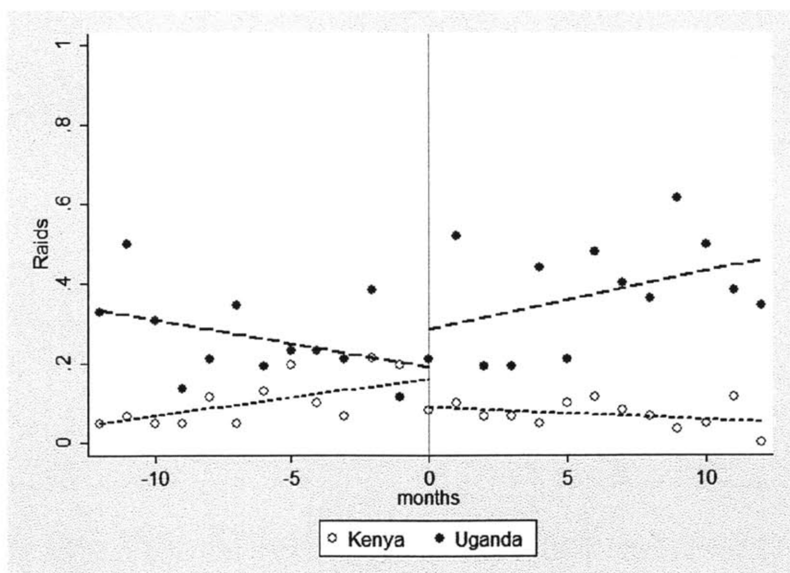


Figure 2-11: Raid Frequency by Country (12 months pre- and post- disarmament)

Note: Time series plot of the average monthly raid frequency in Ugandan and Kenyan sublocations.

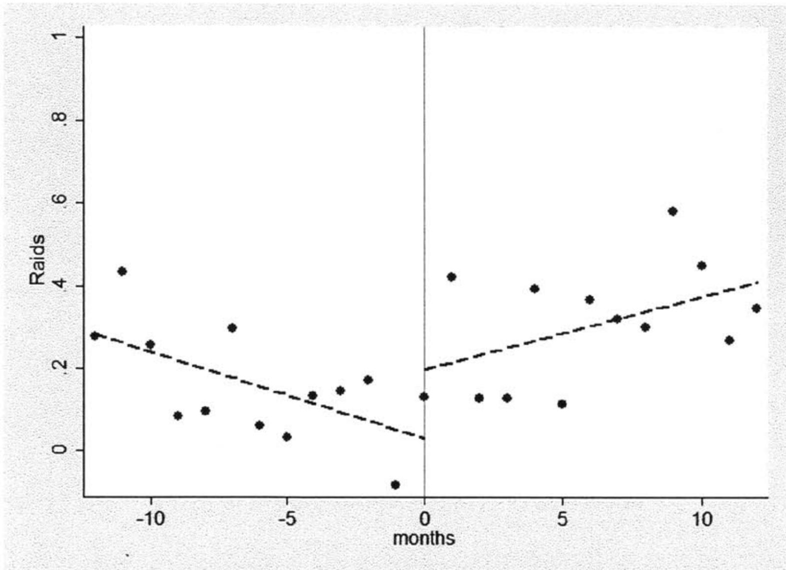


Figure 2-12: Difference in Raid Frequency between Uganda and Kenya (12 months pre- and post- disarmament)

Note: Time series plot of the difference in the average monthly raid frequency between Ugandan and Kenyan sublocations.

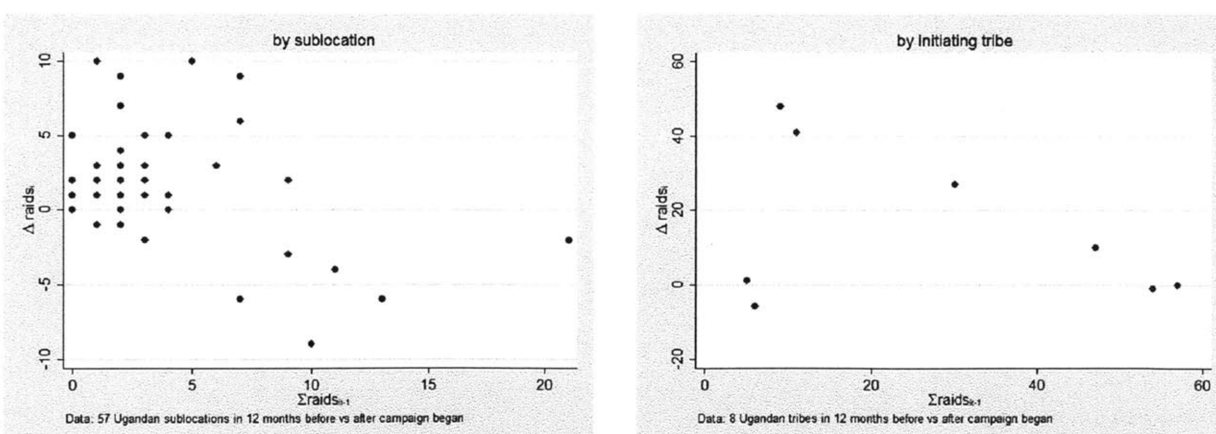
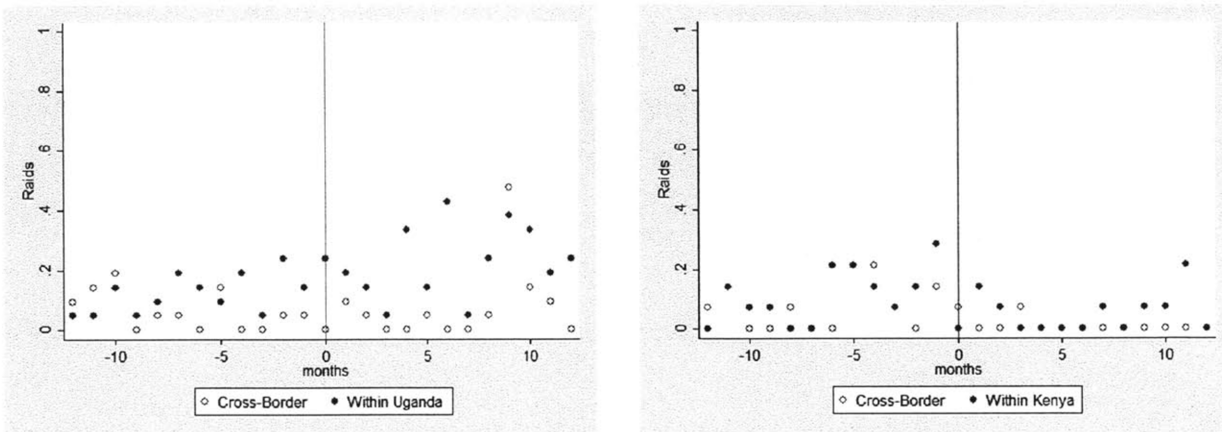


Figure 2-13: Evidence of Disarmament Impact by Pre-Raid Vulnerability and Strength

Note: $\Delta raids_i$ denotes the change in number of raids between the 12 months before and after the campaign began, and $\Sigma raids_{i,t-1}$ denotes the number of raids that a tribe initiated in the 12 months before the disarmament campaign, or the number of raids that occured in a sublocation in the 12 months before the disarmament campaign.



(a) Uganda (b) Kenya

Figure 2-14: Times series trends : Raids near to the Uganda-Kenya Border (12 months pre- and post- disarmament)

Note: Time series plot of the average monthly raid rate in sublocations that are geographically centred within 20 km of the Uganda-Kenya border.

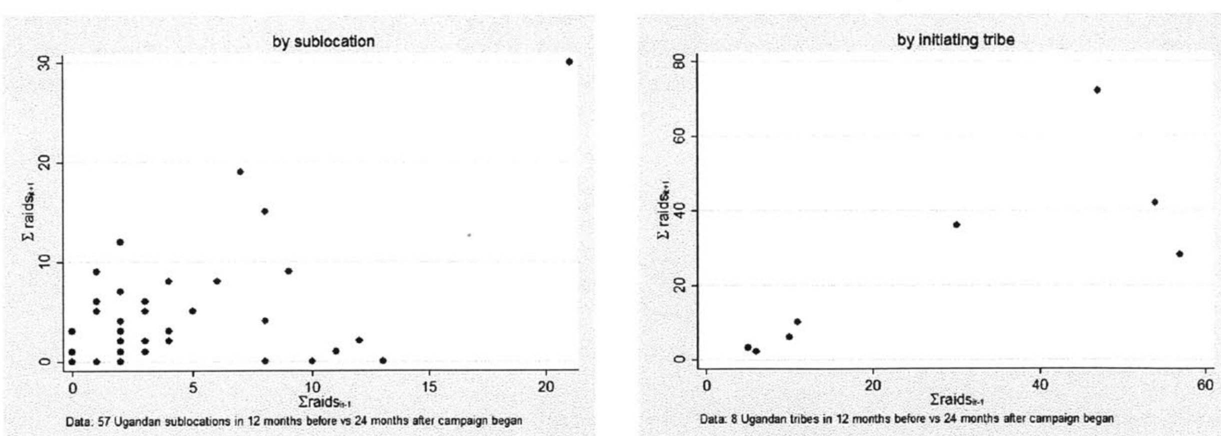


Figure 2-15: Evidence of Long Term Impacts by Pre-Raid Vulnerability and Strength

Note: $\Sigma raids_{i,t+1}$ denotes the number of raids 12-24 months after the campaign began, and $\Sigma raids_{i,t-1}$ denotes the number of raids 12-0 months before the disarmament campaign.

2.9 Appendix Theory

Proposition 3

Given $\frac{1}{2}B - C(\overline{G},\overline{G}) < 0$ and $\frac{1}{2}B - C(\underline{G},\underline{G}) > 0$, then $\chi_1 > \chi_2$.

Proof

$\chi_1 > \chi_2 \iff$

$$\frac{\frac{\overline{G}}{\overline{G}+\underline{G}}B - C(\overline{G},\underline{G})}{\left(\frac{\overline{G}}{\overline{G}+\underline{G}}B - C(\overline{G},\underline{G})\right) - \left(\frac{1}{2}B - C(\overline{G},\overline{G})\right)} > \frac{\frac{1}{2}B - C(\underline{G},\underline{G})}{\left(\frac{1}{2}B - C(\underline{G},\underline{G})\right) - \left(\frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G})\right)}$$

$\iff$

$$\frac{W}{W-X} > \frac{Y}{Y-Z} \iff -WZ > -XY$$

where

$$W \equiv \frac{\overline{G}}{\overline{G}+\underline{G}}B - C(\overline{G},\underline{G})$$

$$X \equiv \frac{1}{2}B - C(\overline{G},\overline{G})$$

$$Y \equiv \frac{1}{2}B - C(\underline{G},\underline{G})$$

$$Z \equiv \frac{\underline{G}}{\underline{G}+\overline{G}}B - C(\underline{G},\overline{G})$$

and $W > Y$ as:

$$\frac{\overline{G}}{\overline{G}+\underline{G}} > \frac{1}{2} \text{ and } C(\overline{G},\underline{G}) < C(\underline{G},\underline{G})$$

and $-Z > -X$ as:

$$C(\underline{G},\overline{G}) > C(\overline{G},\overline{G}) \text{ and } \frac{\underline{G}}{\overline{G}+\underline{G}} < \frac{1}{2}$$

Therefore,

$$-WZ > -XY \iff \chi_1 > \chi_2$$

Proposition 4

If $2C(\overline{G},\overline{G}) > C(\overline{G},\underline{G}) + C(\underline{G},\overline{G}) > 2C(\underline{G},\underline{G})$, implying that cross-type interactions are less costly than H-type only interactions but more costly than L-type only interactions, the average conflict cost of a raid strictly decreases when L-types also raid.

Proof

For a given p, if the average cost when an L-type raids is lower than average cost when an H-type raids, then when L-types raid as well as H-types, the average cost of any raid must decrease.

The average conflict cost when an L-type raids is:

$$p(C(\overline{G},\underline{G}) + C(\underline{G},\overline{G})) + (1-p)2C(\underline{G},\underline{G})$$

while the average cost when an H-type raids is:

$$p2C(\overline{G},\overline{G}) + (1-p)(C(\overline{G},\underline{G}) + C(\underline{G},\overline{G}))$$

For the average conflict cost of an L-type to be less than the average conflict cost of an H-type, the following condition must be satisfied:

$$p\left(2C(\overline{G},\overline{G}) - [C(\overline{G},\underline{G}) + C(\underline{G},\overline{G})]\right) + (1-p)\left([C(\underline{G},\overline{G}) + C(\overline{G},\underline{G})] - 2C(\underline{G},\underline{G})\right) > 0$$

This will be satisfied if $2C(\overline{G},\overline{G}) > C(\overline{G},\underline{G}) + C(\underline{G},\overline{G}) > 2C(\underline{G},\underline{G})$, and then once L-types raid as well as H-types, the average conflict cost of a raid will fall.

Predicted Changes to Livestock Taken per Raid

The model predicts a decrease in the number of livestock taken per raid when both types raid rather than just H-types and this decrease scales with the relative arms levels of the different types. The number of livestock taken per raid when just H-types raid is:

$$p_0\frac{1}{2}B + (1-p_0)\frac{\overline{G}}{\overline{G}+\underline{G}}B$$

where p_0 denotes the initial proportion of H-types. The number of livestock taken per raid when both types raid is:

$$\frac{1}{2}B$$

Thus, the relative decrease in number of livestock taken per raid is predicted to be

$$\frac{1}{2}p_0 + (1-p_0)\frac{\overline{G}}{\overline{G}+\underline{G}} - \frac{1}{2} \in \left[0, \frac{\overline{G}}{\overline{G}+\underline{G}}\right]$$

2.10 Appendix Tables

Table 2.14: Weekly Survey Reports on Disarmament Measures in Kenya

	Weapons Reduce	Bullet Commodity
$disarm_t$	-0.12	0.15
p-value for test: $\delta_1 = 0$	(0.06)*	(0.26)
N	510	510
Pre-disarmament mean in Kenya	0.22	0.70

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Note: $disarm_t$ is an indicator variable for observations in Kenya after May 2006. These regressions include controls for field monitor fixed effects. The pre-disarmament means give the mean level of each survey measure before the disarmament campaign. The survey measures record each field monitors response to the questions: (1) Has a disarmament, weapons reduction or buyback program been initiated? (2) Are bullets in use as an exchangeable commodity? 0 indicates strong disagreement and 1 indicates strong agreement. A wild cluster bootstrap is used to compute p-values for a decrease in weapons reduction and an increase in the bullets measure. These p-values are reported in parenthesis and the bootstrap is clustered at the level the survey measures are collected.

Table 2.15: Raids in Kenya

	Weekly Raid Rate	
$bullets_{it}$	0.025	
	[0.054]	
$weapons_{it}$		-0.052
		[0.069]
R^2	0.01	0.01
N	510	510
mean	0.244	0.269

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: The unit of analysis is the weekly number of raids reported by each field monitor in Kenya, $bullets_{it}$ denotes their survey response to the question: are bullets in use as an exchangeable commodity? and $weapons_{it}$ denotes their survey response to the question: has a disarmament, weapons reduction or buyback program been initiated? Their response is coded 0 for disagree and 1 for agree. Standard errors clustered by field monitor.

Table 2.16: Raids - Robustness Checks

	(1a)	(1b)	(1c)	(1d)	(3a)	(3b)	(3c)	(3d)
$disarm_t$	-0.01	-0.01	-0.01	-0.01	-0.02	-0.00	-0.02	-0.00
	[0.02]	[0.02]	[0.02]	[0.02]	[0.04]	[0.03]	[0.04]	[0.04]
$uganda_{ic} * disarm_t$	0.12	0.08	0.10	0.09	0.15	0.14	0.14	0.17
	[0.05]**	[0.05]*	[0.05]**	[0.07]	[0.08]*	[0.05]***	[0.08]*	[0.12]
$disarm_t * t$					-0.01	-0.00	-0.01	-0.01
					[0.01]**	[0.00]	[0.01]**	[0.01]**
$uganda_{ic} * disarm_t * t$					0.04	0.00	0.04	0.05
					[0.01]***	[0.01]	[0.01]***	[0.02]***
R^2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
N	7,821	7,821	7,759	6,109	7,821	7,821	7,759	6,109
Pre-disarm. mean in Uganda	0.24	0.27	0.24	0.28	0.24	0.27	0.24	0.28
Sample	24mth	40mth	UPDF	farbr	24mth	40mth	UPDF	farbr

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, $uganda_{ic}$ is an indicator variable for observations in Uganda, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). The (b) regressions use 20 months before and after the announcement to evaluate the impact of the campign, the (c) regressions omit observations for months in which a sublocation reported a forceful UPDF visit, while the (d) regressions also exclude sublocations that have centres within 20km of the Uganda-Kenya border. All the regressions control for fixed effects at the sublocation level - the geographic unit at which raids are reported, and errors are clustered at this level too. The sample for Kenya excludes sublocations that have centres within 20km of the Uganda-Kenya border. Month fixed effects and the full time series are used to deseasonalize the data. Top-coding the results to record a maximum of 4 raids per month per sublocation does not change the results and affects only 22 observations.

Table 2.17: Monitoring - Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Ugandan sublocations					
	Monthly Banditry Rate			Monthly Assault Rate		
$disarm_t$	-0.00	-0.04	-0.05	0.04	0.13	0.12
	[0.01]	[0.03]*	[0.03]	[0.03]	[0.05]**	[0.05]**
t		0.00	0.00		-0.01	-0.00
		[0.00]	[0.00]		[0.00]**	[0.00]
$disarm_t * t$			-0.00			-0.01
			[0.00]			[0.01]
Difference at 6 months	-0.00	-0.04	-0.05	0.04	0.13	0.09
	[0.01]	[0.03]*	[0.04]	[0.03]	[0.05]**	[0.04]*
R^2	0.00	0.00	0.00	0.01	0.02	0.02
N	4,108	4,108	4,108	4,108	4,108	4,108
	Kenyan sublocations					
$disarm_t$	-0.01	-0.00	-0.00	-0.00	-0.02	-0.02
	[0.01]	[0.01]	[0.01]	[0.01]	[0.03]	[0.03]
t		-0.00	-0.00		0.00	0.00
		[0.00]	[0.00]		[0.00]	[0.00]*
$disarm_t * t$			0.00			-0.00
			[0.00]			[0.00]
Difference at 6 months	-0.01	-0.00	0.00	-0.00	-0.02	-0.05
	[0.01]	[0.01]	[0.02]	[0.01]	[0.03]	[0.03]*
R^2	0.00	0.01	0.01	0.00	0.01	0.01
N	4,819	4,819	4,819	4,819	4,819	4,819
	All sublocations					
Difference-in-difference at 6 months	0.01	-0.03	-0.05	0.04	0.18	0.18
	[0.01]	[0.03]	[0.04]	[0.03]	[0.06]**	[0.05]**
Pre-disarmament mean in Uganda	0.034	0.034	0.034	0.109	0.109	0.109
R^2	0.00	0.00	0.00	0.01	0.01	0.01
N	8,927	8,927	8,927	8,927	8,927	8,927

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: $disarm_t$ is an indicator variable for observations between May 2006 - April 2007, the 12 months following the campaign announcement, while t is a linear time trend with t set to zero at May 2006 (e.g., April 2006 has $t = -1$). All the regressions control for fixed effects at the sublocation level - the geographic unit at which conflict data is reported, and errors are clustered at this level too. The reported "difference-in-difference" is the estimated impact of the disarmament 6 months into the post period in Uganda relative to Kenya. The reported "pre-disarmament mean in Uganda" is mean banditry and assault rate in Uganda in the 12 months before the campaign was announced. Month fixed effects and the full time series are used to deseasonalize the data.

Chapter 3

How does stress affect social interactions?

3.1 Introduction

Conflict is an inherently unproductive activity and its occurrence is not fully understood. Why do some individuals choose to fight, while others abstain? This question is central to understanding why violence prevails in many social and economic settings. For example, what triggers civilians to participate in violent uprisings or to take up arms during civil wars, and what motivates criminals to offend or resort to violence? Recent work has found that both poverty [66] [36] [24] and previous exposure to violence or hostile behavior [67] [90] [70] can increase the probability that an individual will participate in violence or conflict. While little is known about the mechanism through which both these factors influence antisocial behavior, different schools of work have shown a link between poverty and stress [34] [35] [58] [53] [23], and between exposure to violence and stress [20] [71] [13] [60] [59] [48] [76] [46]. This paper aims to shed light on the relationship between stress and social interactions to elucidate whether this particular pathway can help explain violent behavior. Specifically, through the administration of cortisol and yohimbine we exogenously activate the hypothalamus-pituitary-adrenal axis (HPA) and noradrenergic (NA) system, both of which are implicated during a stress response, and then we measure the participants' behavior in a series of social and non-social tasks in a laboratory experiment.

The fight-or-flight response is generally regarded as the prototypic human response to stress.

For example, a biological response to stress is an increase in blood sugar levels as well as an increase heart rate and elevated blood pressure. This response would seem to prepare us for an increased tendency towards aggressive or reactionary behavior, at least for instrumental purposes, to ensure that we put priority on our own survival and well being ahead of that of others. While this explanation of the manifestation of aggressive behavior seems plausible, there is actually very little evidence of how stress pervades social interactions particularly from a causal perspective. Put differently, although aggressive behavior is commonly associated with stressful confrontations, it is unclear whether aggression is caused by stress or whether aggressive interactions provoke stress. By exogenously manipulating the stress levels of participants and then having participants play interactive games, we are able to address whether stress does in fact facilitate aggressive or antisocial behavior. Simultaneously, we are also able to address an emerging alternative hypothesis that suggests that stress may instead strengthen social relationships as humans try to improve social networks that may be beneficial in situations of stress [98] [94].

Exposure to stress activates two biological systems: the rapidly acting autonomic sympathetic nervous system (ANS) and the slower hypothalamic-pituitary-adrenal (HPA) axis. The activation of these systems leads, respectively, to a rapid release of the catecholamines adrenaline and noradrenaline by the adrenal medulla, followed by a somewhat slower release of glucocorticoids (cortisol in humans) by the adrenal cortex. Via the release of cortisol and noradrenaline, stress affects many brain areas that are important in cognitive functioning, such as the prefrontal cortex, amygdala and hippocampus. In this study, we activate the NA and HPA systems of healthy male adults with the $\alpha 2$-adrenoceptor antagonist yohimbine and the synthetic glucocorticoid hydrocortisone, respectively, and examine their separate and combined effects on several aspects of behavior: trust, trustworthiness, expectations of trustworthiness, willingness to share, willingness to punish, expectations of willingness to punish, generosity, inequity aversion, risk tolerance and patience. These behavioral outcomes are monitored through the actions the participants choose in standard versions of the Trust, Ultimatum and Dictator Games, as well as a lottery game to measure risk preferences and a task that reveals time preferences. We collect saliva samples, for assaying cortisol and alpha-amylase (a biomarker for the adrenergic system), throughout the experiment to measure the participants response to the oral administration of yohimbine and hydrocortisone and to check for any basal differences among participants.

By stimulating both the NA and HPA systems simultaneously as well as in isolation we are addtionally able to investigate whether any changes in social behavior rely on the co-occurrence of glucocoticoids (mainly cortisol in humans) and noradrenergic activity, or if activation of one system is more important than the other. Previous studies have found that behavioral outcomes can depend on whether both systems are activated, rather than just one. For example, the stress effects on the ability to remember words, pictures and statements (declarative memory) and the shift of instrumental behavior from goal-directed to habitual control necessitate co-activation of both systems [85] [84] [101] [89]. Other work, however, has found that hydrocortisone on its own has a fear-reducing effect [91] [19], while yohimbine is associated with greater panic symptoms that lead to less attention to threats [97]. Either of these latter effects could plausibly lower participants' loss-aversion and this may result in changes to their behavior in the social games. Given this, we test for the effects of stimulating each system in isolation as well as their joint stimulation.

3.2 Methods

3.2.1 Participants

Healthy males between the ages of 18-40 years were recruited to participate in the study that took place at the MIT Behavioral Research Lab between the March - May 2012. The participants received a flat fee of $50 and could earn up to an additional $60 in the social games and non-social tasks. Exclusion criteria required that the participants were not a psychology or economics major, weighed no more than 190 lbs, did not smoke more than 5 cigarettes per day on average, nor drink more than 1 bottle of wine or 2 pints of beer per day on average, nor consume cannabis or other drugs, did not take regular medications, did not have a history of psychiatric disorder and had not recently been under severe stress. We also required that participants did not consume alcohol or coffee, or engage in sexual activity for the 24 hours before the study, and we asked participants not to eat or drink anything apart from water and not to engage in strenuous physical activity in the 2 hours before the study. These criteria were made clear when participants signed up for the study and we reminded the participants of the restrictions on food and drink 2 days before they were due to present themselves for the study. This resulted in a sample of 105 healthy male adults, who were randomly assigned to four different conditions: yohimbine only (Y), hydrocortisone only (H), yohimbine and hydrocortisone (Y+H) and placebo (P). Of these participants, 4 have been excluded from analyses because they did not fully understand the games (1 participant), they appeared to be under the influence of recreational drugs (1 participant), they had baseline cortisol above 30 nmol/l (1 participant) or they attended two study sessions (1 participant). The final subsample size of the respective groups was: 25, 25, 25, 26. For the first 9 participants we piloted the study and these participants did not play the Ultimatum or Dictator Games, but did complete all the other tasks.

In general the subsamples showed similar demographic and income measures (see table 3.1). The characteristics upon which the treatment subsamples varied relative to the placebo subsample were: age, weight, whether they had any siblings, whether they were a student, and their political leaning.[1] The participants in the Y and H subsamples were slightly younger (24.8 and 24.3, respectively, vs. 27.8 in the P subsample), more likely to be a student (68% and 64%, respectively, vs. 35%) and held more liberal views (2.44 and 2.36, respectively, vs. 3.19). Participants in the Y subsample were on average heavier as well (167.4 lb vs. 155.3 lb). We also collected psychometric measures at the start of the experiment for all the participants (see table 3.2 and appendix table). Based on a Visual Analog Scale (VAS), where the participants were asked to mark on a 10 cm horizontal line their level of agreement between total disagreement to complete agreement to a series of reflective statements, we obtained measures of how the participant regarded themself as well as other people. In response to the statement "I am a very trustworthy person" we found that participants in the Y+H subsample had a lower opinion of themselves (78.8 vs. 87.0), and to the statement, "It is more important to think of oneself than others" we found participants in the H subsample disagreed more strongly (39.2 vs 51.8) (see table 3.2). We also asked the participants

[1]Of these characteristics, only whether they were a student or had any siblings (0.05 significance level), and their political leaning (0.10 significance level), varied across all the subsamples according to an F-test.

to rate their perceived level of negative emotion (distress, upset, guilty, ashamed, hostile, irritable, nervous, jittery, scared, afraid) using a 7-point Positive and Negative Affect Scale (PANAS) and this did not reveal any significant differences between the subsamples at the start of the experiment (see appendix table).

Given these variations in demographic characteristics and personal views, we present results that include controls for age, weight, student status, having any siblings, political leaning and each participant's initial VAS scores for "trustworthiness" and "selfishness" based on the statements, "I am a very trustworthy person" and "It is more important to think of oneself than others", respectively.

3.2.2 Social and non-social tasks

The participants were asked to play in 3 social games: the Trust Game, the Ultimatum Game, and the Dictator Game, and to respond to questions during tasks that elicited both their time and risk preferences. All the games and tasks were carried out on computers using the zTree software. [37]

The **Trust Game** asked the participants whether or not they would like to send $4 to another player. If they chose to send $4, they were informed that the other player would receive triple the amount they sent, that is $12. This other player could choose to send any integer amount between $0-$12 back to them. We used this game to obtain a measure of trust for the sending player and a measure of trustworthiness for the receiving player. The response for the receiving player was elicited using the strategy method so we asked all receiving players what they would do if they received $12, regardless of whether or not the social interaction led them to this scenario. In addition, we asked the sending players to tell us what they expected their partner to return to provide us with a secondary measure of trust. The participants played the Trust Game twice: once as a sender and once as a receiver. For all the interactive games we told the participants that they would be randomly matched to partners, they would not remain with the same partner for more than one iteration of a game or across games, and we provided no feedback on their performance or their partners' actions until the very end of the experiment. This was to minimize any type of reputation or learning effects on their behavior, and so that their behavior could not be influenced by how their partners were playing.

The **Ultimatum Game** again involved a sender and receiver role, which each participant played once each, but in this case the sender chose how much of $10 they would like to offer to the receiver. For example, they could choose to send $4 and keep $6 for themself.[2] The receiver, however, was able to veto any offer they were unsatisfied with and force both players to receive zero.[3] We used this game to measure the participants willingness to share and to punish as well as their inequity aversion. We also asked the sender what was the minimum amount they thought their partner would accept to measure expectations of the willingness to punish.

The **Dictator Game** involved only one active role, the sender, although the players were randomly matched to receivers for the purpose to calculating payoffs. The sender chose how much of $10 they would like to offer to the receiver, who was not allowed to refuse their offer. For example, if the sender chose to keep $10 for themself there was nothing the receiver could do about this. We used this game to measure generosity and inequity aversion. We also asked the sender how much they thought other players were likely to send to measure expectations of generosity.

In the **Time Preference Task** the participants were asked a series of 18 questions soliciting their preference between two payments at different points in time. In the first six questions the payments could be made on the day of the experiment or in 6 months, in the next six questions the payments could be made on the day of the experiment or in 12 months, and in the last 6 questions the payments were either in 6 months or 12 months. This enabled us to calculate indifference points for each of the participants for payments made at six month intervals and calculate both the rate at which participants discounted future outcomes (δ) and their level of present bias (β), according to Laibson's quasi-hyperbolic discounting model.[4] [51]

In the **Risk Preference Task** we offered the participants a choice between a relatively "safe" lottery, where the possible payments were $2 and $1.75, and a more "risky" lottery, where the possible payments were $4 and $0.25. We offered the choice of lotteries with increasingly better

[2] We only allowed splits by whole integer amounts.

[3] We elicited this decision through the strategy method, by asking for each possible split ($10/$0, $9/$1,...,$0/$10) whether the receiver would accept an offer.

[4] For example, the value of a income stream x is valued as $U(x) = x + \beta\delta x + \beta\delta^2 x + \beta\delta^3 x + \ldots$.

odds (from p=0.1 to p=1) of obtaining the higher payment in each lottery so that we could observe the point at which each participant was willing to take the more risky lottery and calculate their risk index.

3.2.3 Procedure

The experiment sessions lasted between 2-2.5 hours and were scheduled between 12 noon to 8 pm in order to control for diurnal variations in cortisol secretion. Each session included between 4 - 12 participants. On arrival at laboratory the participants were seated at separate computer desks with partitions and were not allowed to communicate with each other, use their cell phones or read personal material. Once seated at the desks, the participants were asked to read and sign their consent forms. Individually we called participants to be screened by a clinical nurse before administering any drugs. When all the participants for a session had arrived we took an initial salivary sample. While the participants were waiting to be screened, we had them read instructions and complete a set of practice questions on the social and non-social tasks. We immediately checked all the practice questions and explained mistakes that participants had made to ensure they had a full comprehension of the tasks before they attempted them.

Once all the participants had been screened, at about 30 minutes after their arrival time, we took another saliva sample and had them fill in a short questionnaire on their current level of negative emotions using the 7-point Positive and Negative Affect Scale and their view of themself and others using the visual analogue scale. We then administered the treatment drugs. Each participant received two tablets which either contained: 20mg yohimbine and one placebo, 60mg hydrocortisone and one placebo, 20mg yohimbine and 60mg hydrocortisone, or two placebo. The placebo tablets contained lactose and all the tablets looked identical. We then waited for 50 minutes before starting the tasks so that the drugs could take affect. During this time we handed out neutral reading material (National Geographic, March 2012) and 30 minutes after administering the drugs we took a third saliva sample. At 50 minutes, we took a fourth saliva sample and had them complete a second questionnaire of the same content as the first to assess any changes in those psychometric measures. Then we started them on the social and non-social tasks. The order of tasks was: time preference task, risk preference task, trust game, ultimatum game, dictator game. Once all the tasks were finished, the participants completed the a demographic survey and provided a fifth saliva sample. Participants were then called individually for payment and an exit health screening, before leaving the laboratory.

3.2.4 Endocrine stress responses

Saliva samples, for assaying cortisol and alpha-amylase levels, were collected using a commercially available sampling device (Salivette, Sarstedt, Numbrecht, Germany). Saliva collection took place at five time points: initial (-30 minutes), baseline (-1 minutes), and then at +30, +50 and +70 minutes. After each experimental session, samples were stored at -20 C until they were biochemically analysed.

Psychological stress responses and psychometric measures

To measure subjectively perceived levels of stress, we gave participants a visual analogue scale at baseline (-1 minutes) and just before the social and non-social tasks (+50 minutes). At these time points we also elicited their level of negative emotions using the 7-point Positive and Negative Affect Scale and their view of themself and others using the visual analogue scale (see appendix figures), as was discussed earlier.

3.3 Results

3.3.1 First Stage Results

The H and Y+H subsamples experienced a substantial increase (+371 nmol/l, SE=43.5 nmol/l, $p<0.01$) in their salivary cortisol levels that peaked at +50 minutes, just before they undertook the social and non-social tasks, (see figure 3-1 and table 3.4). The Y and Y+H subsamples experienced increases to salivary alpha-amylase by +50 minutes (+52 u/ml, SE=13.3 u/ml, $p<0.01$), although this biomarker looks to have continued rising between +50 to +70 minutes, while the tasks were being completed (see figure 3-2 and table 3.5). Interestingly, baseline alpha-amylase is negatively correlated with changes to cortisol, suggesting that participants with higher baseline noradrenergic activity were slightly less susceptible to increased HPA system activity. The Y subsample had a higher initial level of alpha-amylase (see figure 3-2), although this difference was not signifcant and did not affect the increase in alpha-amylase induced by exogenous administration of yohimbine.

Figure 3-3 demonstrates that subjects were not able to correctly guess which drug they had been administered.

3.3.2 Trust Game

The results from the Trust Game indicate that the participants in the Y subsample may have been more willing to trust other people. The participants from this subsample were 25% more likely to send \$4 (SE=12 p.p., $p<0.05$, see table 3.6) but this result is only significant under the full set of controls. Further sensitivity analysis on this result showed that it depended on controlling for initial levels of trustworthiness as recorded through the visual analog scale, which was itself positively correlated with sending \$4, as would be expected. Once this control is included in the regression, we find that participants from the Y subsample were significantly more likely to send \$4 to their partners.

There is also weak evidence that the Y+H subsample showed a significantly lower level of trustworthiness (returned \$1.08 less, SE=0.67, $p<0.10$, see figures 3-4 and 3-5, and table 3.6). However, once the control for the initial level of trustworthiness is included the Y+H subsample no longer show any discernible differences in the amount they were willing to return in the Trust Game.

In addition, we find that higher baseline alpha-amylase is significantly negatively correlated with both the measure of trust and trustworthiness ($p<0.05$), while higher baseline cortisol is significantly negatively correlated with the measure of trust ($p<0.05$). These findings are consistent with two threads of previous research. First, that exposure to violence can elevate baseline indicators for stress, such as salivary cortisol, and second, that exposure to violence can increase hostile behavior. Thus, while not helping us unravel the causality of the relationship, these results provide further indications of the correlation between stress and antisocial behavior, as measured through reductions in trust and trustworthiness.

3.3.3 Ultimatum Game

We find very limited evidence for behavioral differences across the drug conditions in the Ultimatum Game. The coefficient estimates from the regression analysis suggest that the H subsample may have been more willing to punish (15-17% more likely to refuse offers below $5) but these results were not significant (see figures 3-6 and 3-7, and table 3.7). Measures of the time it took participants to make decisions suggest that the Y subsample took less time to decide how much to accept, perhaps suggesting they were less concerned by their outcome which would be consistent with lower attention to threat and reduced loss aversion (see table 3.9).

3.3.4 Dictator Game

Again, we find limited evidence for behavioral differences across the drug conditions in the Dictator Game. Based on the sign of the coefficient estimates, there is some indication that the Y+H subsample were less generous, expected others to be less generous (gave $0.69 less, and expected others to give $0.49 less) and took a longer time to decide how much to give (7.1 seconds, SE=4.2, $p<0.10$), but the results for the actions were not significant (see figure 3-8, and tables 3.8 and 3.9). The H subsample, however, had a higher expectation of the generosity of others when the full set of controls are included ($1.08, SE=0.61, $p<0.10$).

3.3.5 Risk Preferences

There were no differences in risk preferences between the drug conditions (see figures 3-9 - 3-11 and table 3.10).

3.3.6 Time Preferences

There were no differences in time preferences between the drug conditions (see figures 3-12 - 3-14 and table 3.11). There were, however, concerns over the participants internal inconsistency, since their revealed preferences in this specific task were not constant. For example, we started each series of 6 questions by asking whether they would prefer \$15 at an earlier time point or \$30 at a later time point and re-asked this question at the end of the series. A high proportion of participants (34-45%) gave different responses to these identical questions.

3.3.7 VAS Post surveys

The visual analog scale post survey at +50 minutes revealed that Y+H subsample felt more stressed (6.94, SE=3.67, $p<0.10$), less trust towards others (-6,57, SE=3.77, $p<0.10$), less willing to help others (-6.29, SE=2.67, $p<0.05$), that other people were less fair (-5.18, SE=2.90, $p<0.10$), and were less likely to return a lost wallet (5.33, SE=3.12, $p<0.10$). These results were robust to controlling for the participants initial VAS scores and the full set of controls. The VAS score on personal fairness for the H subsample was also lower (-7.18, SE=3.16, $p<0.05$).

However, in contrast to the findings from the Trust Game, the VAS post survey scores show that trusting others and being trustworthy was postively correlated with baseline cortisol, indicating that when asked to self-report individuals with higher levels of baseline cortisol thought they were more trustworthy and willing to trust others.

3.4 Discussion

Our preliminary findings suggest mixed results. There is some indication that the exogenous stimulation of the NA system or the exogneous stimulation of the HPA axis in isolation may encourage more pro-social behavior, as our initial results found that the participants given 20mg yohimbine showed an increase in trustworthiness in the Trust Game, while participants given 60mg of hydrocortisone anticipated greater generosity in the Dictator Game. However, these results were sensitive to the regression specification and are unlikely to be robust if we adjust our p-values to take into consideration the multiple inferences explored in the study. Given this, we are keen to verify these findings by extending the number of participants in the study.

The concurrent stimulation of both systems, our primary method for simulating the biological response to stress, did not reveal any robust changes to behavior in any of the social or non-social tasks. It did, however, manifest in lower opinions of the trustworthiness and fairness of other people, as well as a decrease in the value associated with helping other people, as measured through the VAS post-survey. At the same time, within our sample of participants, those with higher levels of baseline cortisol were less trusting in the Trust Game, although they consider themselves more trusting in the self-reported survey measures, and those with higher levels of alpha-amylase were both less trusting and less trustworthy, in the Trust Game, and did not consider themselves more or less trusting or trustworthy in the self-reported survey measures.

In contrast to our proposed hypothesis, the exogenous stimulation of the two biological systems associated with stress did not lead to any statistically detectable increases in anti-social behavior in the interactive tasks, nor did it affect risk or time preferences. It did, however, lead to lower self-reported opinions of the trustworthiness and fairness of other people, and of the value associated with helping other people. Higher baseline cortisol was also associated with greater distrust in other people in the Trust Game, even though these participants did not self-identify a lower willingness to trust others in the self-reported survey measures. Given these initial results, we wish to further explore the relationship between stress and anti-social behavior, and we plan to extend the number of participants in the study to further investigate these results.

3.5 Tables

Table 3.1: Summary Statistics - Demographic and Income Data

	Y	H	Y+H	Placebo
age	24.8*	24.3**	25.9	27.8
	(1.07)	(1.08)	(1.23)	(1.24)
weight	167.4**	160.3	157.9	155.3
	(3.38)	(3.11)	(4.01)	(4.23)
black	0.12	0.12	0.16	0.23
	(0.07)	(0.07)	(0.07)	(0.08)
disposable income ($ per month after bills)	476.8	390.4	479.2	439.8
	(77.17)	(129.13)	(122.36)	(85.10)
are you currently in debt?	0.40	0.52	0.44	0.54
	(0.10)	(0.10)	(0.10)	(0.10)
how much do you donate per year? ($)	67.5	77.6	134.5	102.5
	(23.16)	(23.89)	(51.74)	(43.66)
do you have any siblings?	0.80	0.96	0.80	1.00
	(0.08)*	(0.04)	(0.08)*	(0.00)
what is your parents' annual income?	218,100	169,100	88,100	103,000
	(117,100)	(45,800)	(10,900)	(21,500)
are you a student?	0.68**	0.64**	0.40	0.35
	(0.10)	(0.10)	(0.10)	(0.10)
how important is religion is your life?	2.80	3.08	3.12	3.96
	(0.42)	(0.39)	(0.47)	(0.40)
how liberal/conservative are you?	2.44*	2.36*	3.28	3.19
	(0.26)	(0.29)	(0.32)	(0.36)
smoker	0.20	0.08	0.12	0.23
	(0.08)	(0.06)	(0.07)	(0.08)
N	25	25	25	26

Notes: "how important is religion is your life?" is scaled 1=not at all, 7=very important; "how liberal/conservative are you?" is scaled 1=very liberal, 7=very conservative.

Table 3.2: Summary Statistics - Pre-Treatment VAS scores

	Y	H	Y+H	Placebo
(0=don't agree at all, 100=completely agree)				
stressed	10.9	11.7	12.6	13.8
	(2.47)	(3.19)	(2.79)	(3.76)
punishment	42.3	45.9	55.0	53.3
	(4.14)	(4.45)	(4.11)	(5.60)
otherstrust	60.5	55.5	56.3	59.5
	(3.35)	(4.16)	(4.25)	(3.97)
metrust	82.2	82.9	78.8*	87.0
	(1.94)	(3.76)	(4.17)	(2.38)
othersgenerous	50.7	48.6	44.8	50.0
	(3.88)	(3.40)	(4.69)	(3.85)
megenerous	64.5	68.7	68.3	71.8
	(5.63)	(4.65)	(4.18)	(4.32)
othersfair	54.0	54.4	54.3	52.0
	(4.68)	(3.72)	(4.97)	(4.89)
mefair	72.8	79.1	79.7	80.0
	(4.42)	(3.14)	(3.61)	(2.78)
help	86.7	86.1	83.2	84.9
	(2.61)	(3.50)	(4.04)	(3.48)
share	73.4	81.6	71.3	78.2
	(4.65)	(3.37)	(5.08)	(3.65)
selfish	46.2	39.2*	50.7	51.8
	(4.96)	(4.18)	(4.13)	(5.82)
wallet_trust	20.0	13.8	29.7	21.6
	(4.57)	(4.42)	(5.99)	(4.10)
N	25	25	25	26

Note: The following questions were asked to obtain measures for each outcome. "stressed" - *In this moment, I feel stressed*; "punishment" - *People who break the rules of society should face severe consequences*; "otherstrust" - *People can generally be trusted*; "metrust" - *I am a trustworthy person*; "othersgenerous" - *Most people are generous*; "megenerous" - *I am a generous person*; "othersfair" - *Most people are fair*; "mefair" - *I am a fair person*; "help" - *It is important to help others who have helped me*; "share" - *It is important to share what we have with others*; "selfish" - *It is more important to think of oneself than others*; "wallet" - *If I find a wallet on the street, it's ok to keep it.*

Table 3.3: Summary Statistics for Cortisol and Amylase

	Y			H			Y+H			Placebo		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Cortisol t=4	7.0	1.7	17.0	402.6	42.5	982.7	376.6	3.7	1057.2	7.4	1.7	37.3
Cortisol Increase t=2-4	-2.9	-14.2	10.1	376.6	33.0	974.8	366.5	-6.6	1037.4	-1.0	-9.0	35.4
Amylase t=4	171.0	34.3	420.2	109.1	11.6	416.0	143.4	5.7	459.9	118.5	16.2	353.8
Amylase Increase t=2-4	50.9	-100.2	211.0	1.5	-60.5	124.6	57.0	-48.7	296.7	6.4	-112.4	175.8
Observations	25			25			25			26		

Note: cortisol measured in nmol/l and amylase in u/ml.

Table 3.4: First Stage - Cortisol

	induced cortisol nmol/l				cortisol change nmol/l			
cortisol_group	382.4	371.1			373.5	371.1		
	[41.5]***	[43.5]***			[40.8]***	[43.5]***		
Y+H			369.4	337.9			368.4	337.9
			[51.1]***	[54.5]***			[50.3]***	[54.5]***
H			395.4	403.3			378.5	403.3
			[51.1]***	[53.9]***			[50.3]***	[53.9]***
baseline cortisol nmol/l		0.8		0.7		-0.2		-0.3
		[0.6]		[0.6]		[0.6]		[0.6]
baseline amylase u/ml		-0.4		-0.4		-0.4		-0.4
		[0.2]*		[0.2]*		[0.2]*		[0.2]*
Constant	7.2	504.9	7.2	532.5	-1.9	504.9	-1.9	532.5
	[29.2]	[273.2]*	[29.3]	[274.5]*	[28.7]	[273.2]*	[28.9]	[274.5]*
R^2	0.46	0.58	0.46	0.58	0.46	0.56	0.46	0.57
N	101	92	101	92	101	92	101	92
Controls		X		X		X		X

Note: Y+H and H indicate treatment group and cortisol group indicates subject was in either Y+H or H treatment groups. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish.

Table 3.5: First Stage - Amylase

	induced amylase u/ml				amylase change u/ml			
amylase_group	43.6	51.9			49.9	51.9		
	[19.6]**	[13.3]***			[12.4]***	[13.3]***		
Y+H			29.5	62.1			53.0	62.1
			[24.3]	[16.7]***			[15.4]***	[16.7]***
Y			57.1	42.1			46.9	42.1
			[23.9]**	[16.4]**			[15.2]***	[16.4]**
baseline cortisol nmol/l		0.1		0.1		0.1		0.1
		[0.2]		[0.2]		[0.2]		[0.2]
baseline amylase u/ml		0.9		0.9		-0.1		-0.1
		[0.1]***		[0.1]***		[0.1]		[0.1]
Constant	113.9	-29.9	113.9	-47.5	4.0	-29.9	4.0	-47.5
	[13.7]***	[80.0]	[13.7]***	[81.8]	[8.7]	[80.0]	[8.7]	[81.8]
R^2	0.05	0.68	0.06	0.68	0.14	0.24	0.14	0.25
N	100	91	100	91	100	91	100	91
Controls		X		X		X		X

Note: Y+H and Y indicate treatment group and amylase group indicates subject was in either Y+H or Y treatment groups. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish.

Table 3.6: Reduced Form - Trust Game

	Sent $4		Amount Returned		Return Belief	
Y+H	-0.01	0.11	-1.13	-0.42	-0.55	-0.18
	[0.12]	[0.11]	[0.65]*	[0.59]	[0.66]	[0.67]
Y	0.11	0.25	-0.33	0.45	0.44	0.55
	[0.12]	[0.12]**	[0.65]	[0.61]	[0.67]	[0.69]
H	0.07	0.13	-0.17	0.15	0.10	0.40
	[0.12]	[0.11]	[0.65]	[0.60]	[0.66]	[0.67]
baseline cortisol nmol/l		-0.00		-0.00		-0.02
		[0.00]**		[0.01]		[0.01]**
baseline amylase u/ml		-0.00		-0.01		-0.01
		[0.00]***		[0.00]***		[0.00]**
Constant	0.73	-0.01	4.69	-2.22	4.38	1.02
	[0.08]***	[0.50]	[0.45]***	[2.66]	[0.46]***	[2.98]
R^2	0.01	0.32	0.04	0.33	0.02	0.22
N	101	92	101	92	92	92
Controls		X		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish. Liberal/conservative index has a significant negative coefficient, while trustworthiness has a significant positive coefficient for all outcomes.

Table 3.7: Reduced Form - Ultimatum Game

	Offer at least $5		Only accept at least $5		Accept Belief	
Y+H	0.03	0.08	0.05	0.07	-0.36	-0.26
	[0.13]	[0.15]	[0.13]	[0.12]	[0.42]	[0.44]
Y	0.03	0.10	0.01	-0.05	-0.38	-0.18
	[0.13]	[0.15]	[0.13]	[0.13]	[0.42]	[0.45]
H	0.11	0.15	0.17	0.15	-0.57	-0.49
	[0.13]	[0.15]	[0.13]	[0.12]	[0.42]	[0.44]
baseline cortisol nmol/l		0.00		0.00		0.00
		[0.00]		[0.00]		[0.00]
baseline amylase u/ml		-0.00		-0.00		-0.00
		[0.00]		[0.00]		[0.00]
Constant	0.65	0.98	0.23	-0.66	3.79	1.48
	[0.09]***	[0.66]	[0.09]**	[0.55]	[0.29]***	[1.96]
R^2	0.01	0.14	0.02	0.20	0.02	0.15
N	101	92	101	92	92	92
Controls		X		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish. Trustworthiness has a significant positive coefficient for all outcomes.

Table 3.8: Reduced Form - Dictator Game

	Dictate		Give at least $5		Dictate Belief	
Y+H	-1.10	-0.69	-0.10	-0.09	-0.78	-0.49
	[0.73]	[0.75]	[0.14]	[0.15]	[0.58]	[0.61]
Y	0.75	1.21	0.06	0.07	0.24	0.77
	[0.73]	[0.77]	[0.14]	[0.15]	[0.59]	[0.63]
H	0.08	0.29	0.14	0.14	0.53	1.08
	[0.73]	[0.76]	[0.14]	[0.15]	[0.58]	[0.61]*
baseline cortisol nmol/l		0.00		0.00		-0.01
		[0.01]		[0.00]		[0.01]
baseline amylase u/ml		-0.00		-0.00		0.00
		[0.00]		[0.00]		[0.00]
Constant	2.75	-2.90	0.38	-0.19	2.17	-1.09
	[0.51]***	[3.36]	[0.10]***	[0.67]	[0.41]***	[2.73]
R^2	0.07	0.22	0.03	0.13	0.06	0.19
N	92	92	101	92	92	92
Controls		X		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish. Trustworthiness has a significant positive coefficient for the "Dictate" outcomes.

Table 3.9: Reduced Form - Contemplation Times during Social Games

	Trust decisions				Ultimatum decisions				Dictator decision	
	send		return		offer		accept		give	
Y+H	2.21	2.38	-0.80	-2.18	-0.45	-0.88	-1.08	-1.44	8.19	7.13
	[2.11]	[2.49]	[2.23]	[2.52]	[1.50]	[1.60]	[1.06]	[1.10]	[4.00]**	[4.29]
Y	2.85	2.75	-1.76	-3.87	3.20	1.50	-2.53	-3.52	2.86	0.20
	[2.11]	[2.56]	[2.23]	[2.59]	[1.52]**	[1.64]	[1.07]**	[1.13]***	[4.05]	[4.41]
H	3.49	4.11	1.36	-0.31	2.55	1.40	-0.90	-1.66	7.67	6.01
	[2.11]	[2.51]	[2.23]	[2.54]	[1.50]*	[1.61]	[1.06]	[1.11]	[4.00]*	[4.31]
base. cortisol nmol/l		-0.04		-0.01		0.00		0.01		0.01
		[0.02]		[0.02]		[0.01]		[0.01]		[0.04]
base. amylase u/ml		0.01		-0.00		-0.01		-0.00		-0.02
		[0.01]		[0.01]		[0.01]		[0.00]		[0.02]
Constant	49.27	46.93	45.88	43.01	51.75	45.12	58.21	48.03	45.42	31.30
	[1.48]***	[11.15]***	[1.56]***	[11.28]***	[1.05]***	[7.14]***	[0.74]***	[4.92]***	[2.80]***	[19.19]
R^2	0.03	0.08	0.02	0.15	0.09	0.19	0.06	0.20	0.06	0.15
N	101	92	101	92	92	92	92	92	92	92
Controls		X		X		X		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish.

Table 3.10: Reduced Form - Risk Preferences

	Risk Averse Indicator		Risk Averse Index	
Y+H	-0.02	0.18	-0.18	-0.02
	[0.14]	[0.16]	[0.20]	[0.23]
Y	-0.10	0.07	-0.05	-0.08
	[0.14]	[0.16]	[0.20]	[0.22]
H	0.02	0.19	0.00	0.12
	[0.14]	[0.16]	[0.20]	[0.21]
baseline cortisol nmol/l		-0.00		-0.00
		[0.00]		[0.00]
baseline amylase u/ml		0.00		0.00
		[0.00]		[0.00]
Constant	0.50	0.16	0.43	-0.32
	[0.10]***	[0.71]	[0.14]***	[0.94]
R^2	0.01	0.10	0.01	0.09
N	101	92	83	77
Consistent		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish.

Table 3.11: Reduced Form - Time Preferences

	Beta		Delta	
Y+H	0.09	0.14	-0.05	-0.13
	[0.13]	[0.15]	[0.09]	[0.09]
Y	-0.08	-0.06	-0.01	-0.01
	[0.13]	[0.16]	[0.09]	[0.10]
H	0.14	0.19	-0.11	-0.14
	[0.13]	[0.15]	[0.09]	[0.09]
baseline cortisol nmol/l		0.00		-0.00
		[0.00]		[0.00]
baseline amylase u/ml		0.00		-0.00
		[0.00]		[0.00]
Constant	0.69	-0.01	0.67	1.39
	[0.09]***	[0.68]	[0.06]***	[0.42]***
R^2	0.03	0.06	0.02	0.15
N	101	92	101	92
Consistent		X		X

Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish.

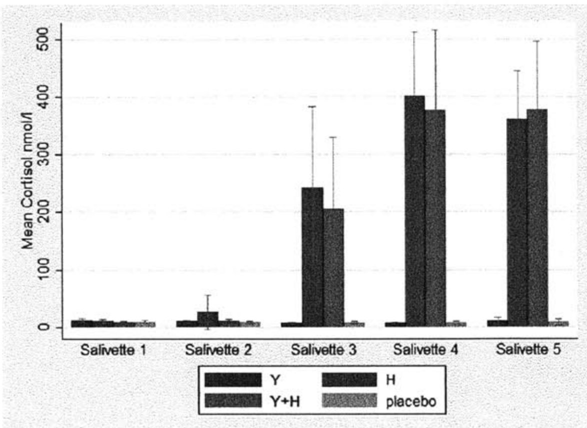
Table 3.12: Reduced Form - VAS post surveys

	Stressed		Trust Others		Trustworthy		Others Fair		Fair		Help		Wallet	
Y+H	6.94	6.31	-6.57	-7.07	-1.94	-1.66	-5.77	-6.40	-5.18	-5.15	-6.29	-4.89	5.33	5.07
	[3.67]*	[4.29]	[3.77]*	[4.01]*	[2.79]	[3.02]	[3.21]*	[3.47]*	[2.90]*	[3.26]	[2.67]**	[2.92]*	[3.12]*	[3.36]
Y	2.70	1.82	-0.52	0.61	-0.54	-0.84	0.32	0.83	-2.96	-1.98	1.38	3.93	1.25	1.31
	[3.67]	[4.33]	[3.80]	[4.07]	[2.79]	[3.05]	[3.24]	[3.52]	[2.97]	[3.23]	[2.71]	[2.95]	[3.13]	[3.38]
H	4.63	4.27	-0.78	-1.22	-3.69	-4.77	-3.40	-3.43	-7.44	-7.18	-1.23	0.26	2.21	2.11
	[3.67]	[4.22]	[3.77]	[3.93]	[2.75]	[2.98]	[3.21]	[3.43]	[2.90]**	[3.16]**	[2.67]	[2.86]	[3.12]	[3.34]
cortisol		-0.02		0.09		0.05		0.04		0.04		0.01		0.00
		[0.04]		[0.04]**		[0.03]*		[0.03]		[0.03]		[0.03]		[0.03]
amylase		0.01		0.01		0.01		0.01		-0.00		0.02		-0.02
		[0.02]		[0.02]		[0.01]		[0.01]		[0.01]		[0.01]*		[0.01]
Constant	0.97	27.70	10.27	26.70	20.79	13.59	13.68	20.90	15.16	11.54	12.05	6.00	-1.55	9.36
	[2.87]	[19.41]	[5.05]**	[17.84]	[5.99]***	[13.50]	[3.72]***	[15.43]	[5.41]***	[14.30]	[5.27]**	[12.91]	[2.42]	[15.45]
R^2	0.49	0.53	0.63	0.68	0.63	0.65	0.73	0.76	0.70	0.72	0.73	0.76	0.84	0.85
N	99	91	91	91	91	91	91	91	91	91	91	91	91	91
Controls		X		X		X		X		X		X		

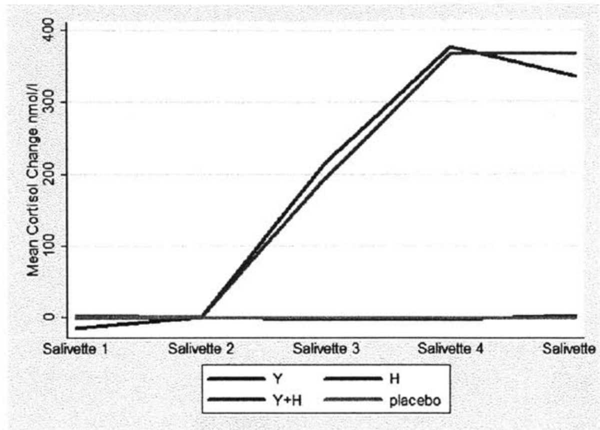
Note: Y+H, Y and H indicate treatment group. Controls include: age, weight, student, having siblings, liberal/conservative index and the VAS scores for trustworthiness and selfish. The corresponding pre-VAS score is always included. Cortisol and amylase refer to the baseline measurements, in nmol/l and u/ml, respectively.

3.6 Figures

3.6.1 Salivette Analysis

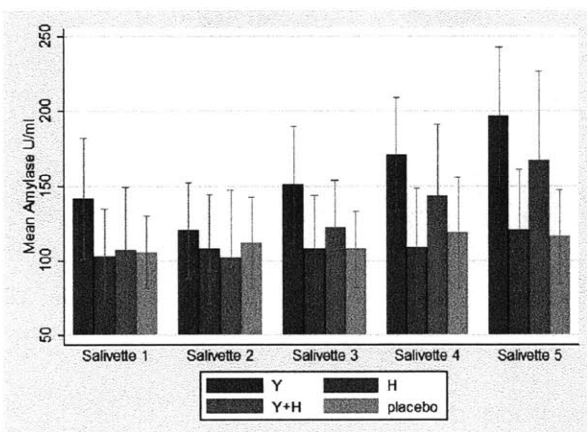


(a) Levels

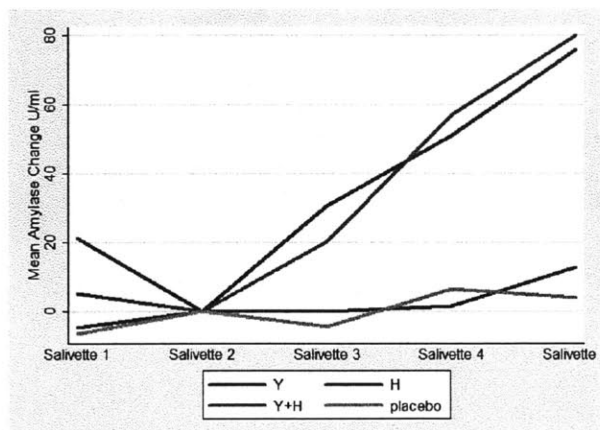


(b) Changes

Figure 3-1: Cortisol Levels and Changes



(a) Levels



(b) Changes

Figure 3-2: Amylase Levels and Changes

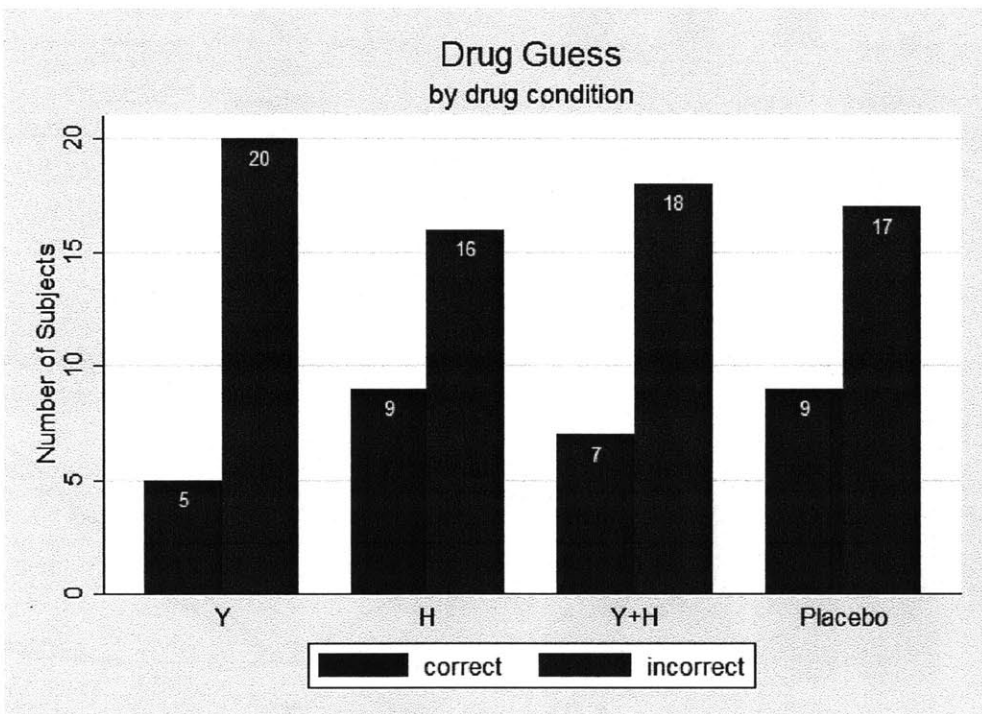
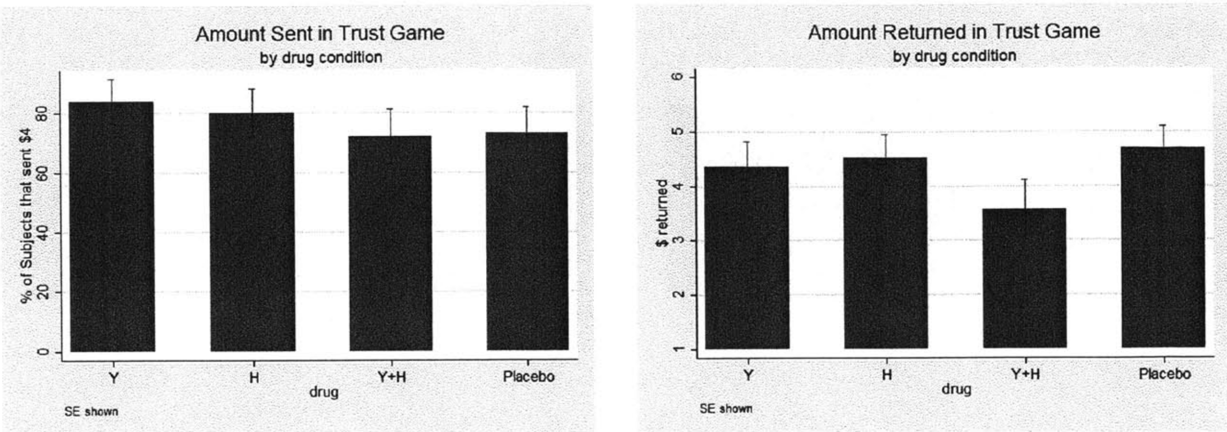


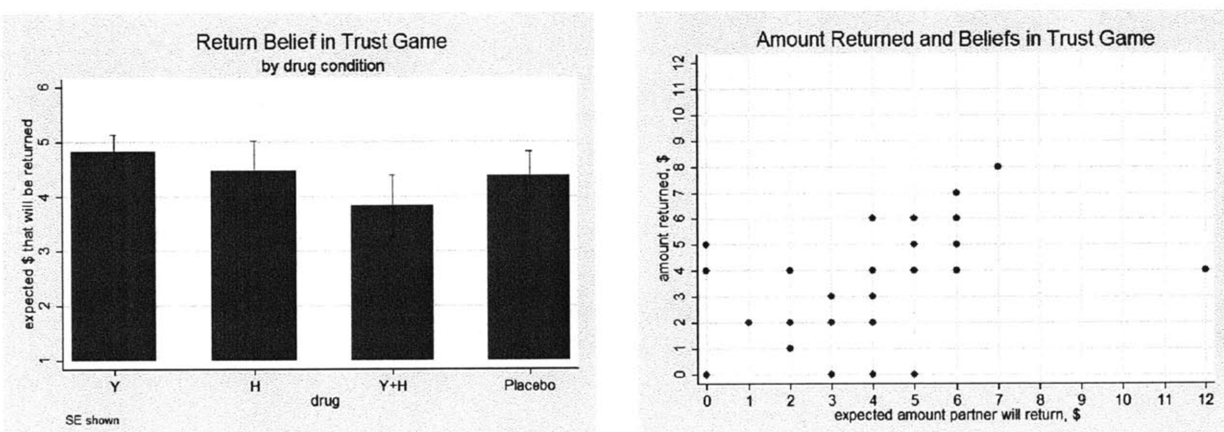
Figure 3-3: Drug Guess

3.6.2 Social Games Analysis



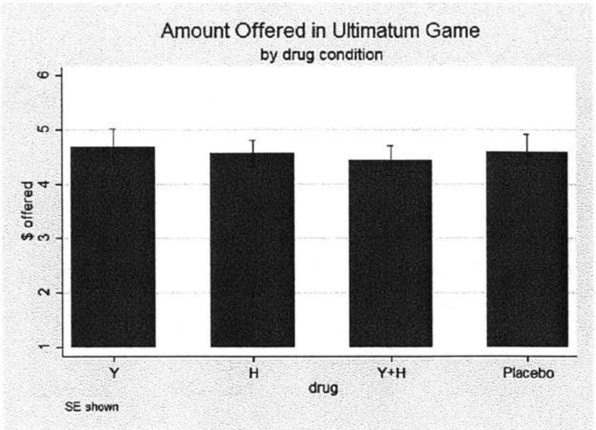
(a) (b)

Figure 3-4: Trust Game - Amount Sent and Returned

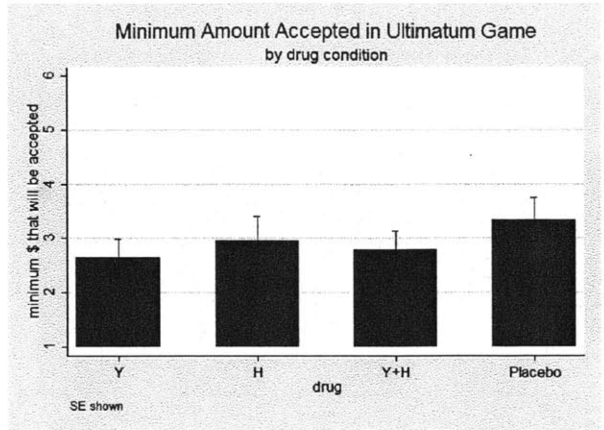


(a) (b)

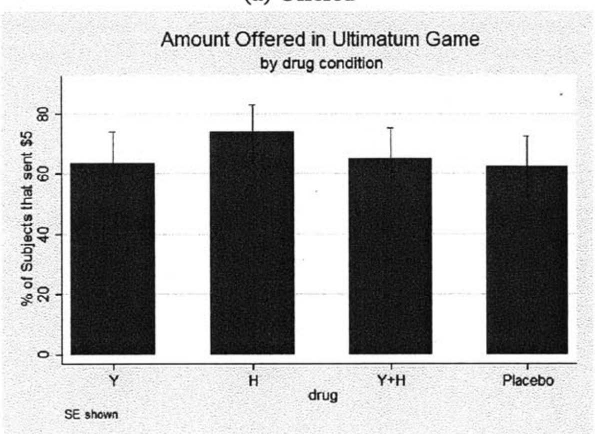
Figure 3-5: Trust Game - Beliefs



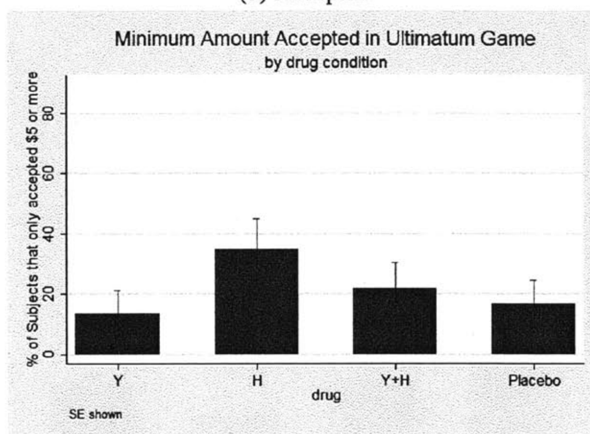
(a) Offered



(b) Accepted

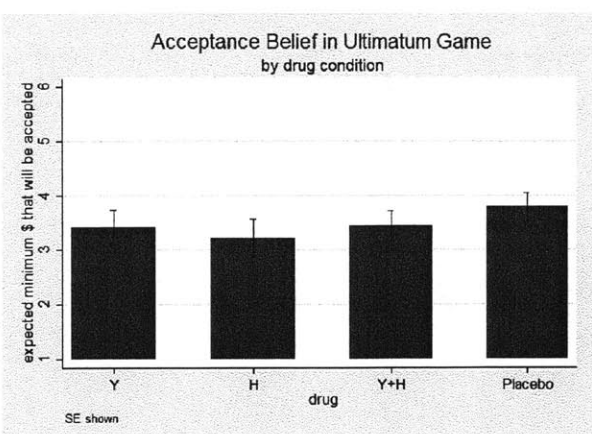


(c) Offered

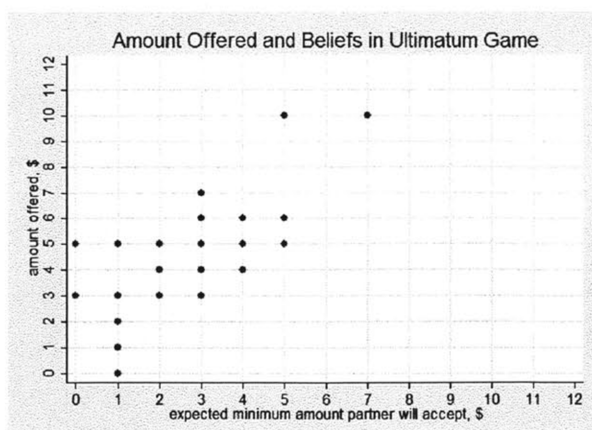


(d) Accepted

Figure 3-6: Ultimatum Game - Amount Offered and Accepted

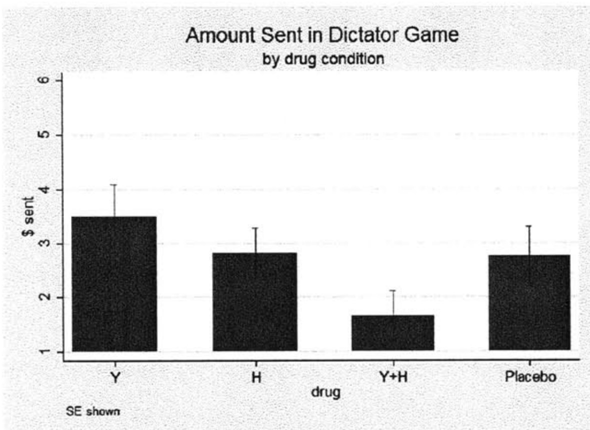


(a)

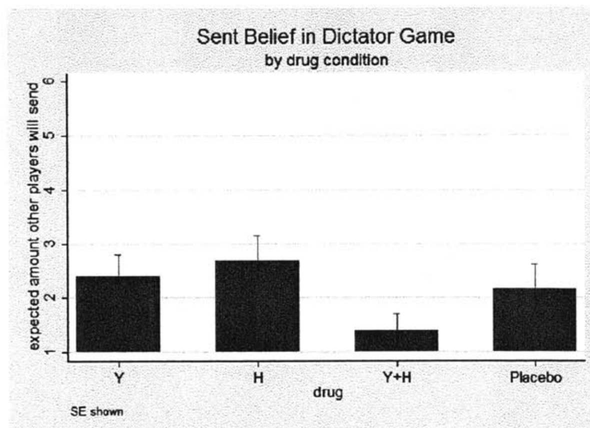


(b)

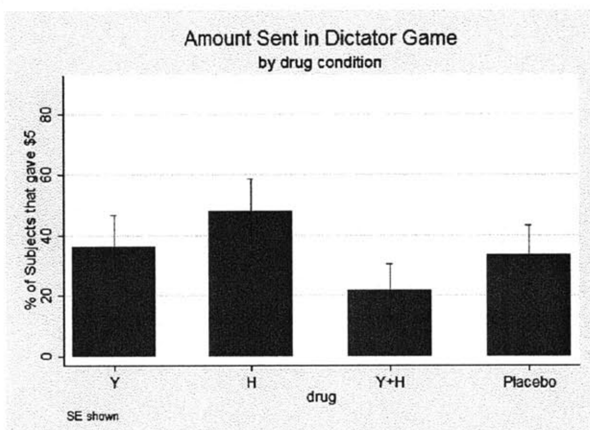
Figure 3-7: Ultimatum Game - Beliefs



(a)



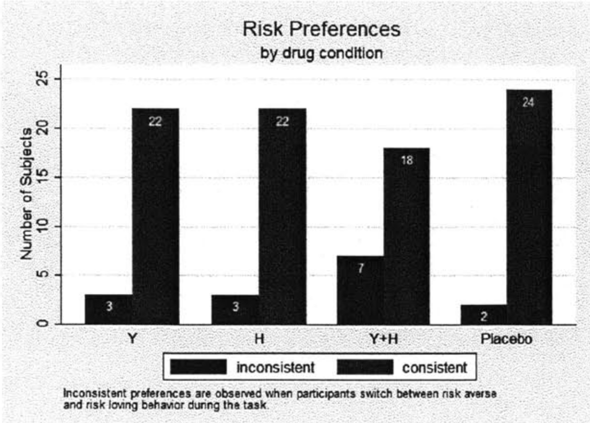
(b)



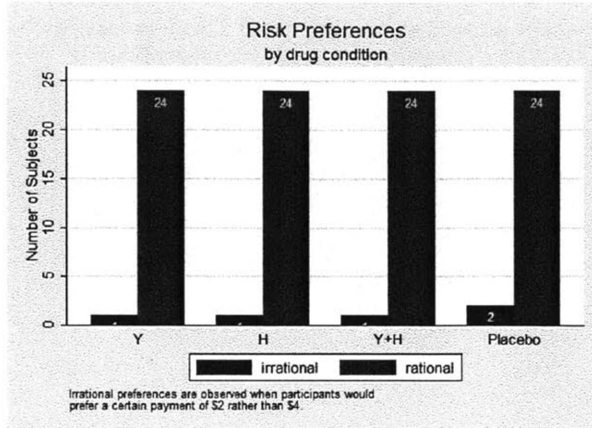
(c)

Figure 3-8: Dictator Game - Beliefs

3.6.3 Non-Social Games Analysis

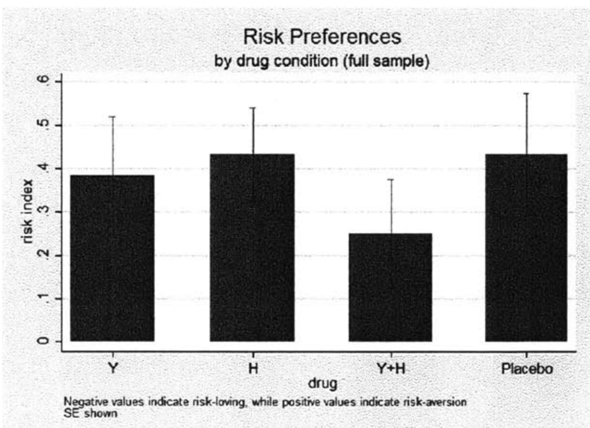


(a) Consistency

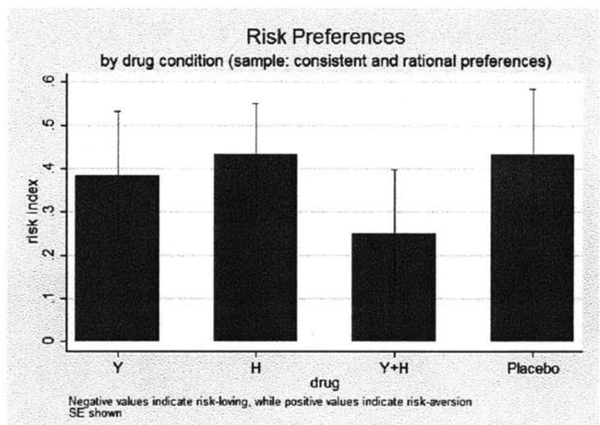


(b) Rationality

Figure 3-9: Risk Preference Task - Behavior Consistency and Rationality

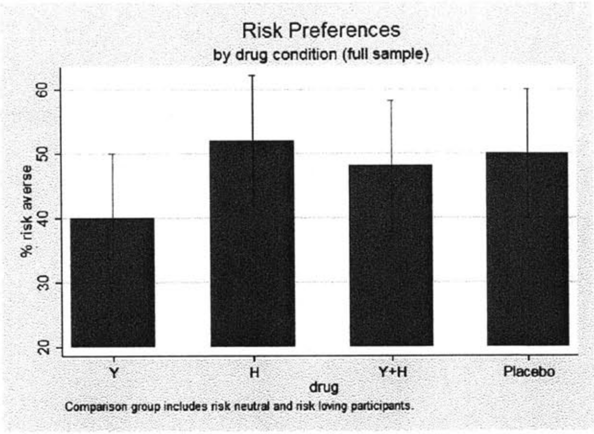


(a) Full sample

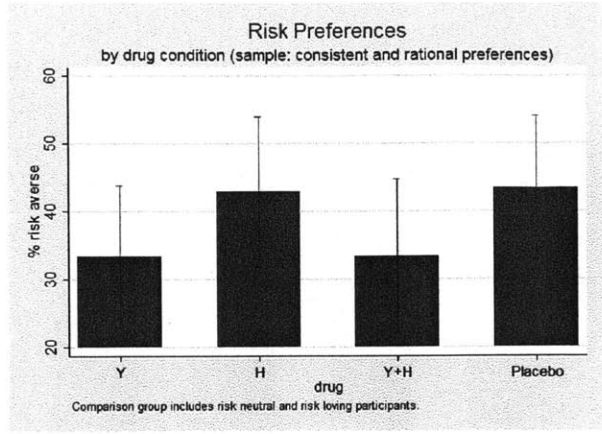


(b) Consistent and rational participants

Figure 3-10: Risk Preference Task - Risk Aversion Index

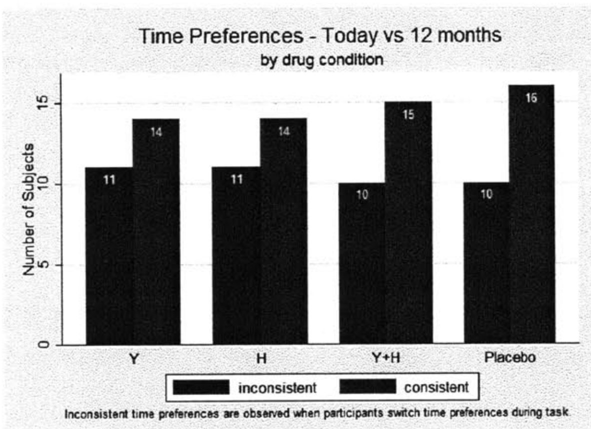


(a) Full sample

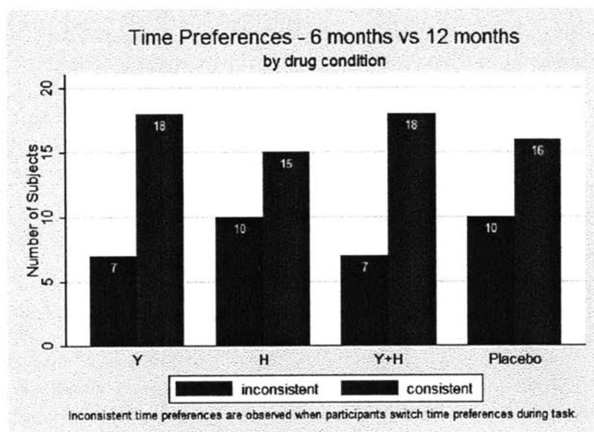


(b) Consistent and rational participants

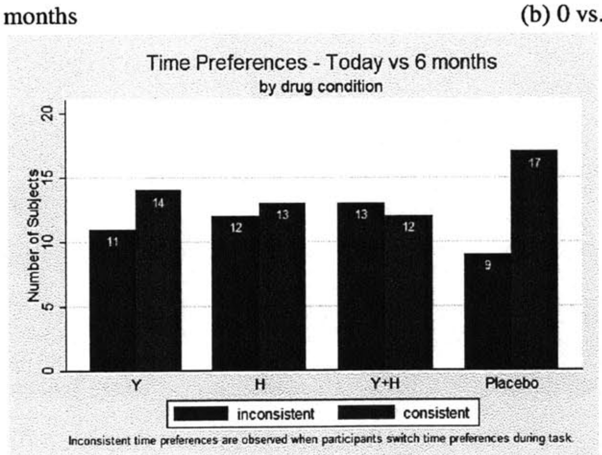
Figure 3-11: Risk Preference Task - Risk Aversion Indicator



(a) 0 vs. 6 months

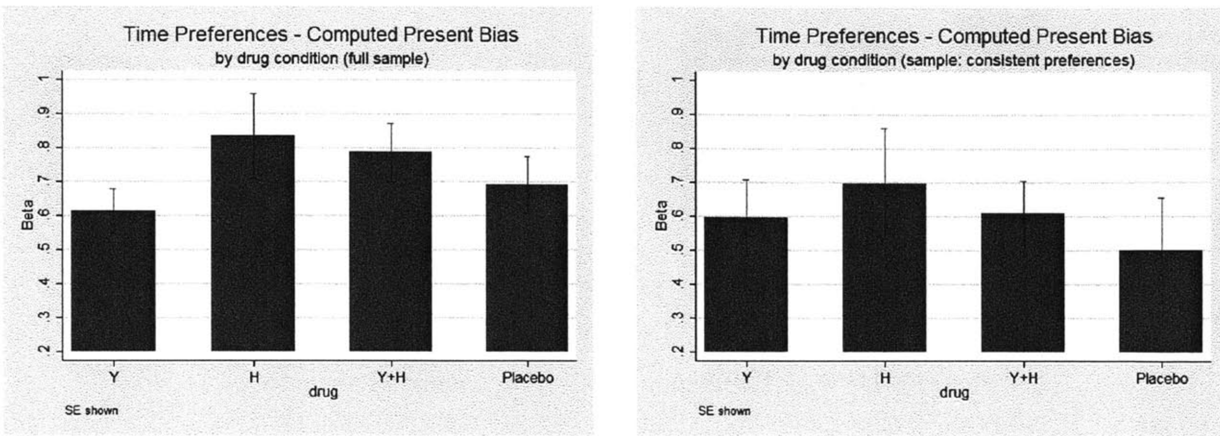


(b) 0 vs. 12 months



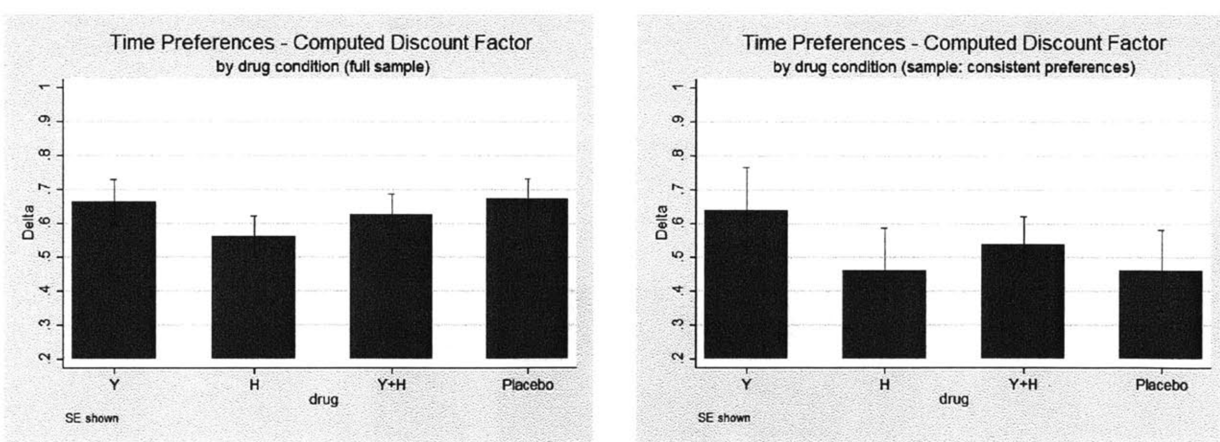
(c) 6 vs. 12 months

Figure 3-12: Time Preference Task - Behavior Consistency



(a) Full sample (b) Consistent participants

Figure 3-13: Time Preference Task - Computed β



(a) Full sample (b) Consistent participants

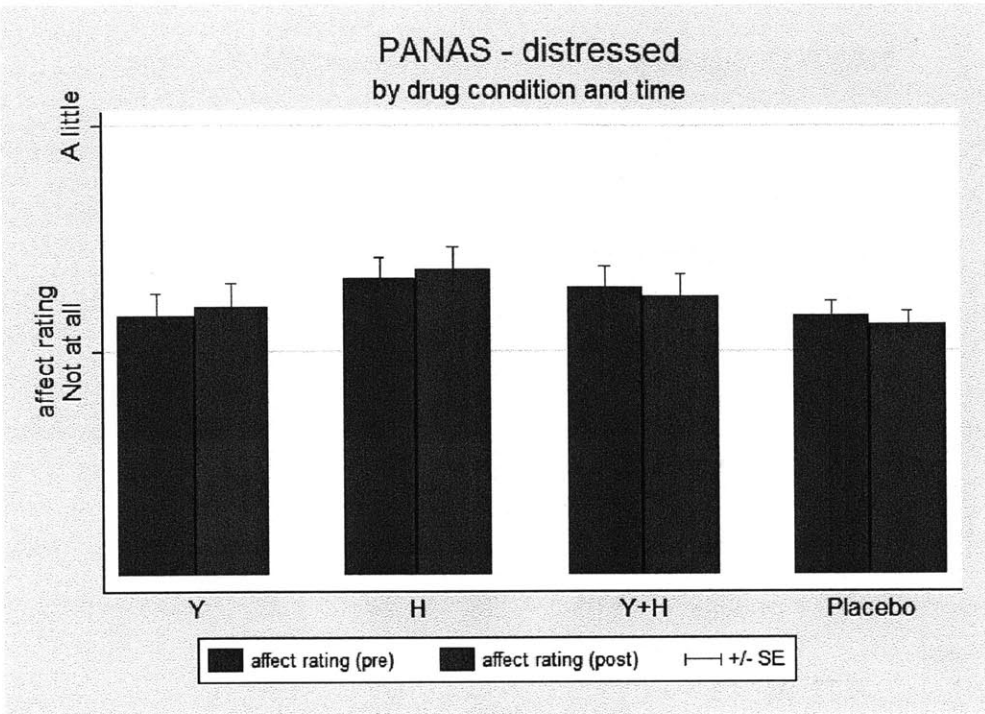
Figure 3-14: Time Preference Task - Computed δ

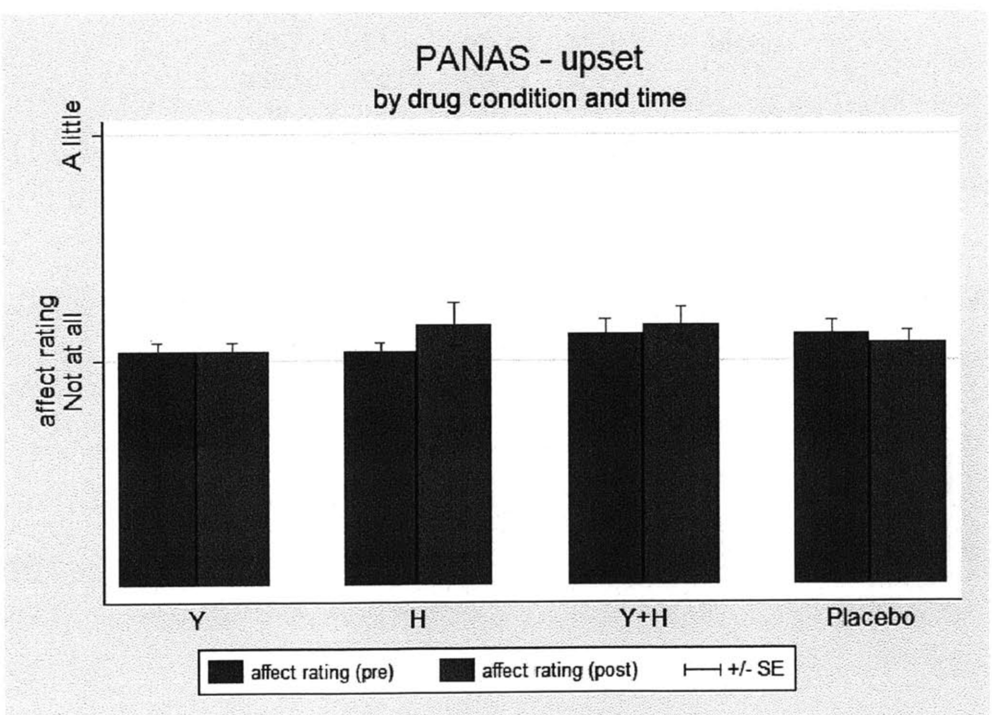
3.7 Appendix

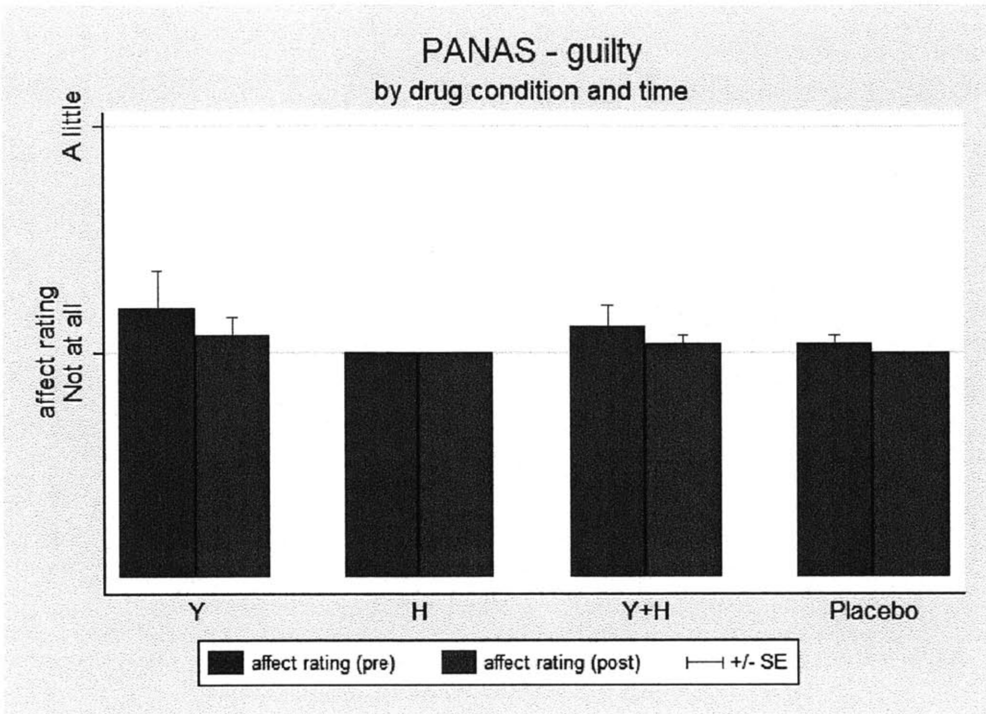
Table 3.13: Summary Statistics - Pre-Treatment PANAS scores

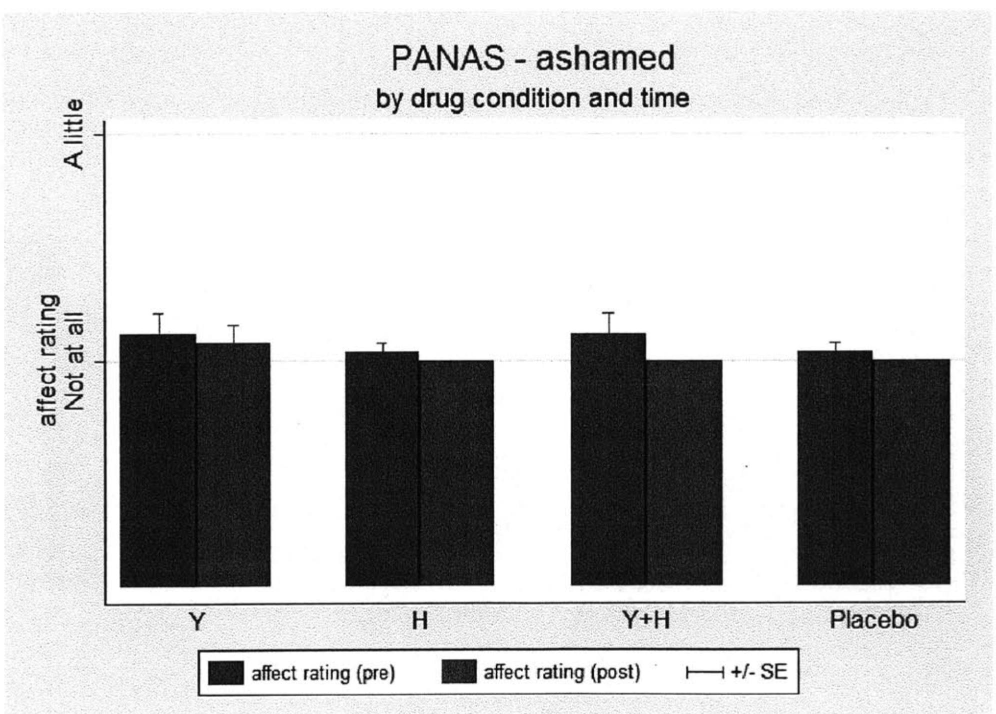
	Y	H	Y+H	Placebo
	(1=not at all, 7=extremely)			
distressed	1.16	1.32	1.28	1.15
	(0.09)	(0.10)	(0.09)	(0.07)
upset	1.04	1.04	1.12	1.12
	(0.04)	(0.04)	(0.07)	(0.06)
guilty	1.20	1.00	1.12	1.04
	(0.16)	(0.00)	(0.09)	(0.04)
ashamed	1.12	1.04	1.12	1.04
	(0.09)	(0.04)	(0.09)	(0.04)
hostile	1.04	1.04	1.08	1.00
	(0.04)	(0.04)	(0.06)	(0.00)
irritable	1.08	1.28	1.24	1.23
	(0.06)	(0.09)	(0.09)	(0.08)
nervous	1.52	1.24	1.44	1.31
	(0.10)	(0.09)	(0.12)	(0.09)
jittery	1.32	1.20	1.16	1.23
	(0.10)	(0.08)	(0.09)	(0.08)
scared	1.00	1.00	1.08	1.00
	(0.00)	(0.00)	(0.06)	(0.00)
afraid	1.04	1.00	1.12	1.00
	(0.04)	(0.00)	(0.09)	(0.00)
N	25	25	25	26

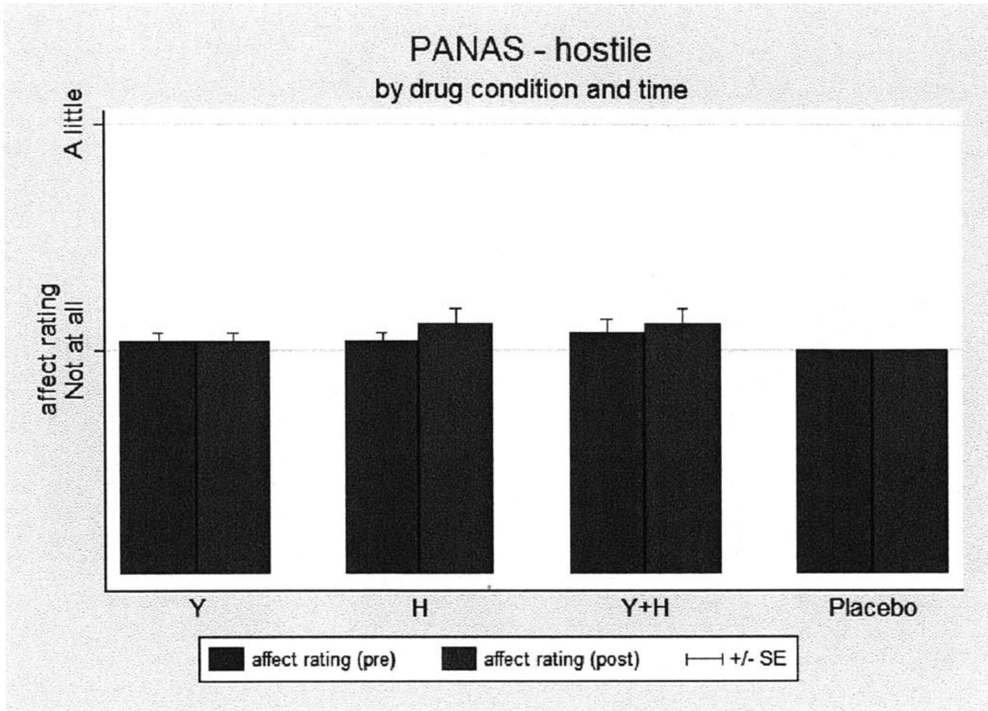
PANAS and VAS Figures

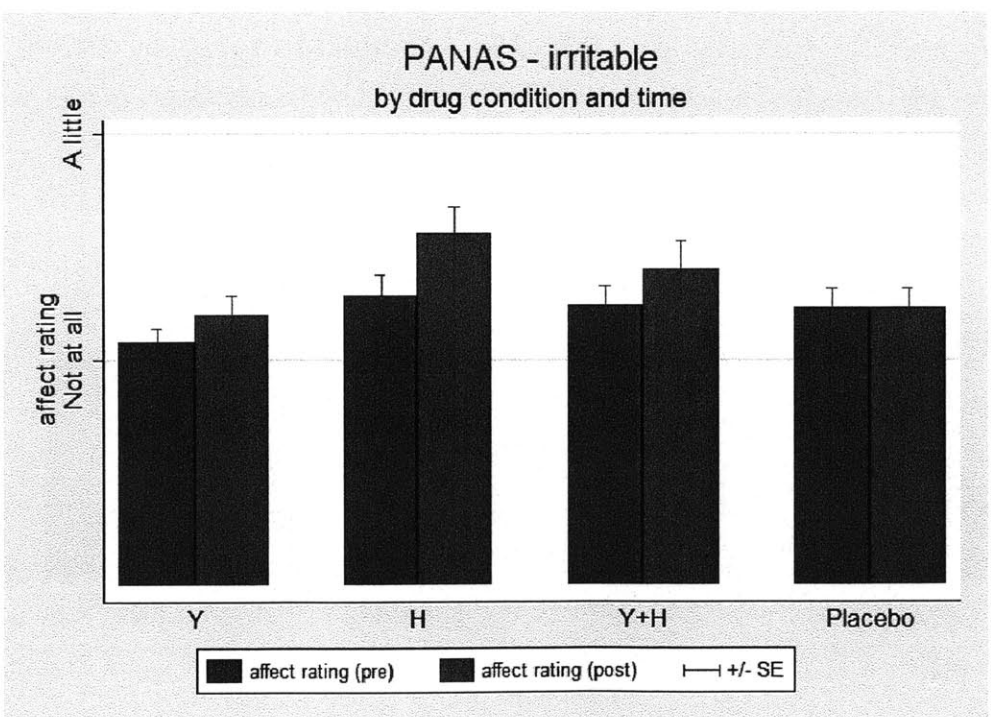

PANAS - distressed
by drug condition and time
A little
affect rating
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

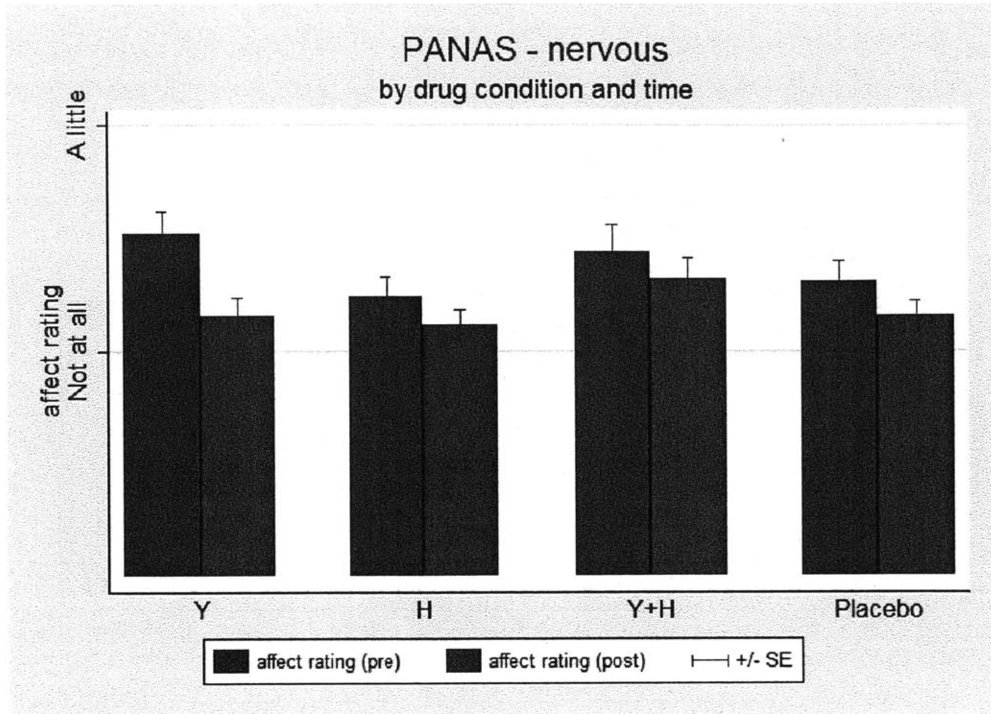

PANAS - upset
by drug condition and time
A little
affect rating
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

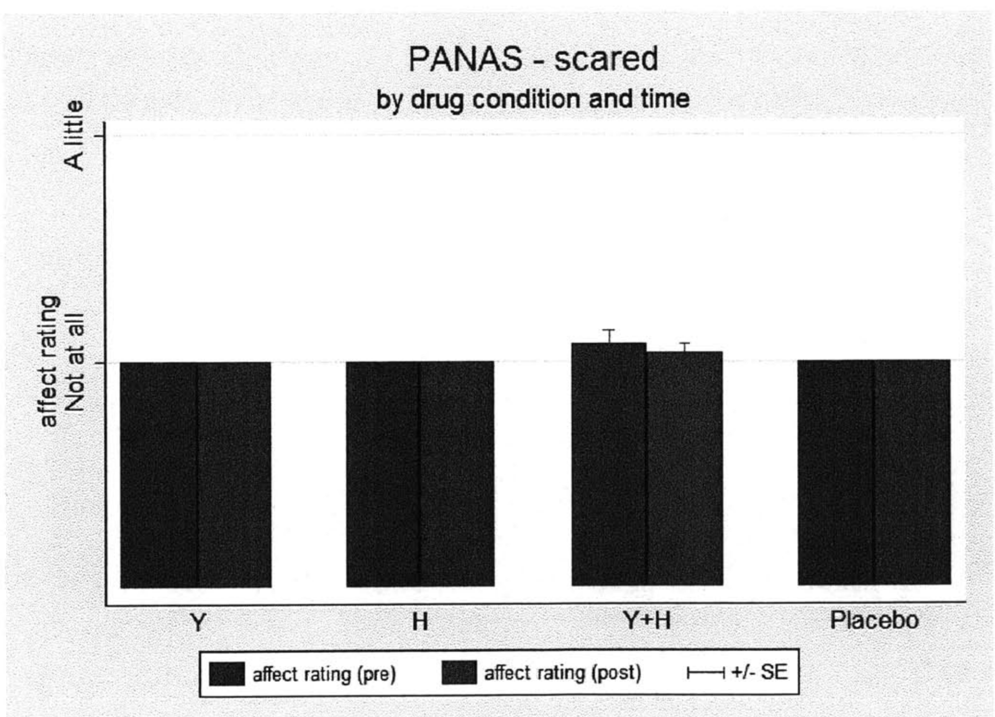

PANAS - guilty
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

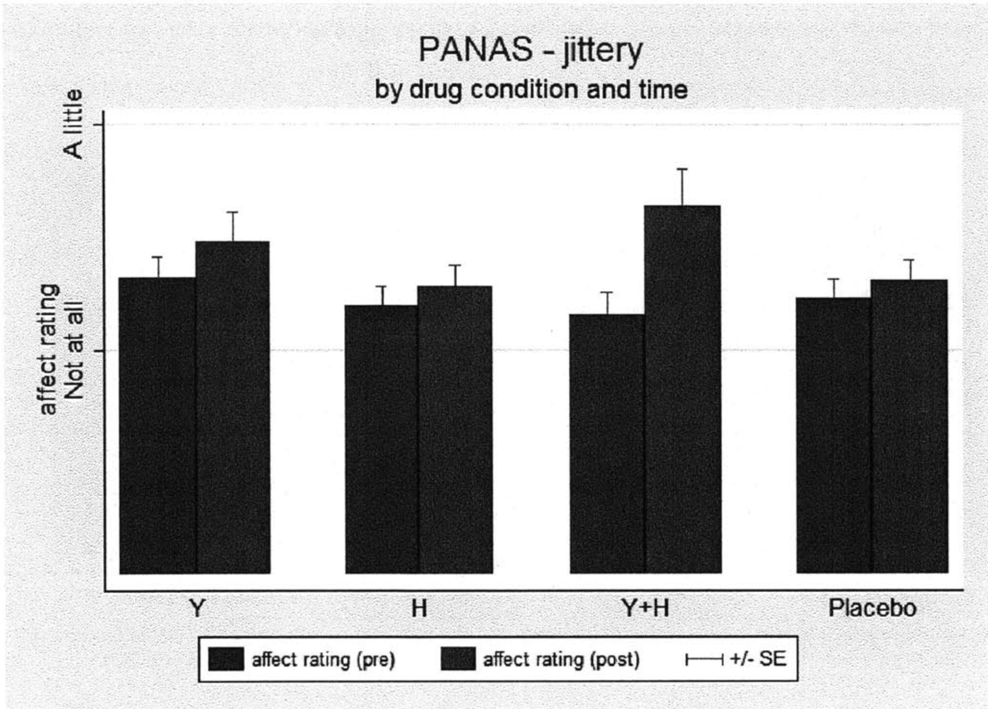

PANAS - ashamed
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

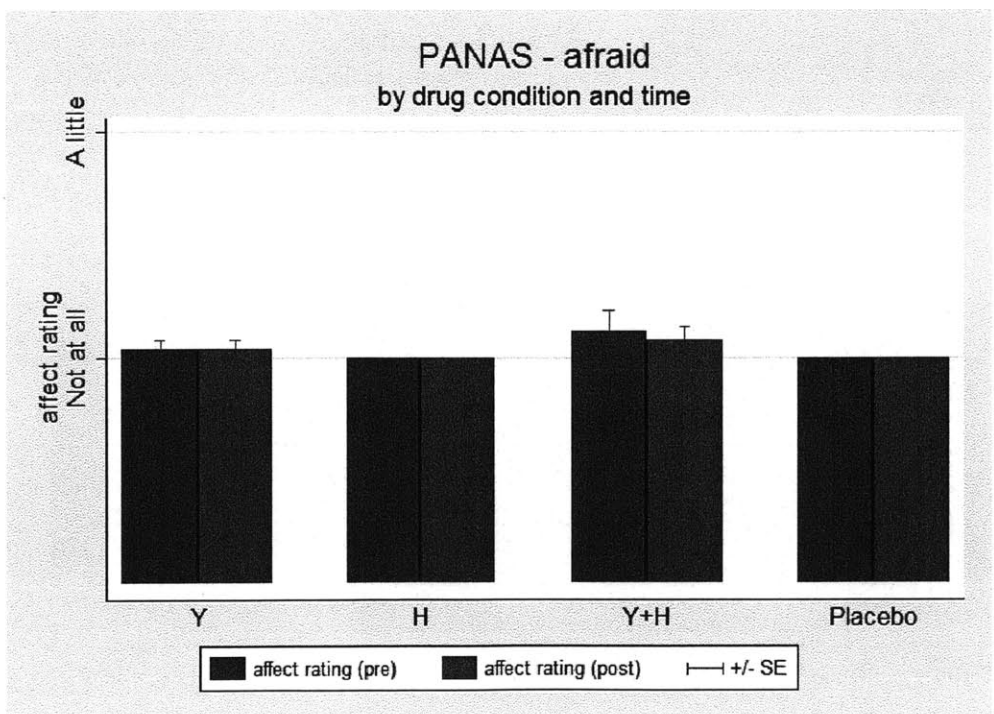

PANAS - hostile
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

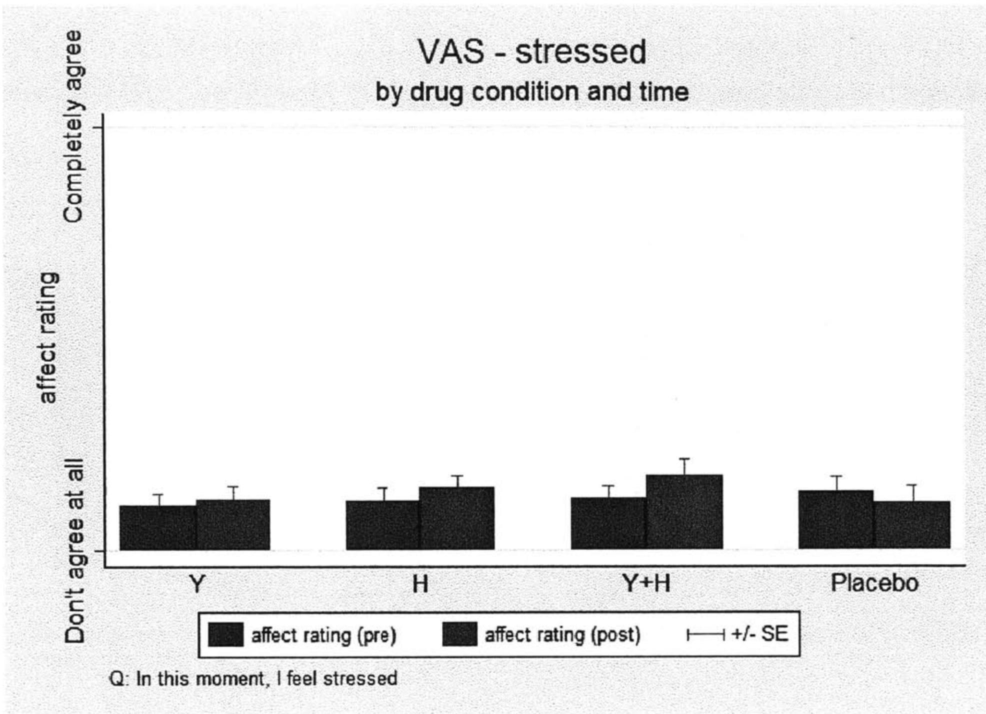

PANAS - irritable
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

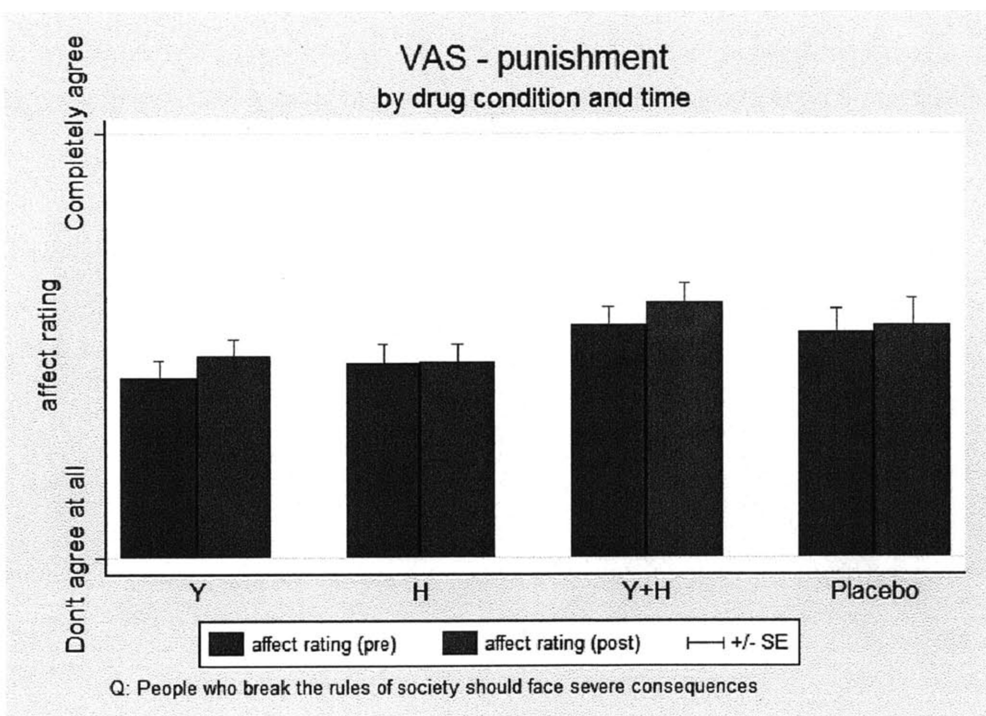

PANAS - nervous
by drug condition and time
A little
affect rating
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

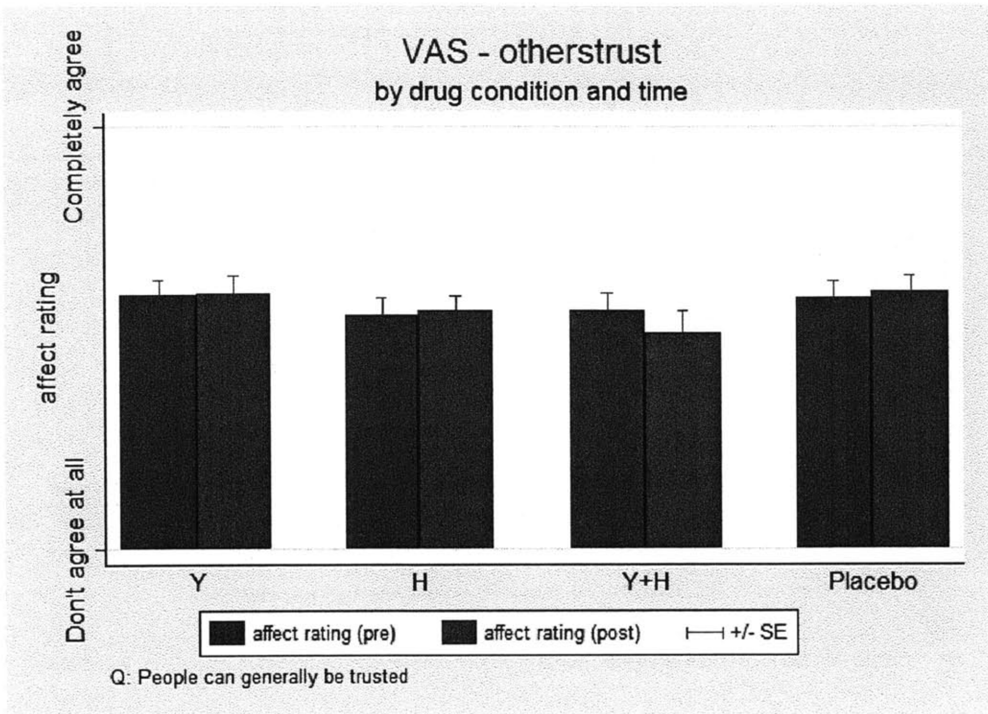

PANAS - scared
by drug condition and time
A little
affect rating
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

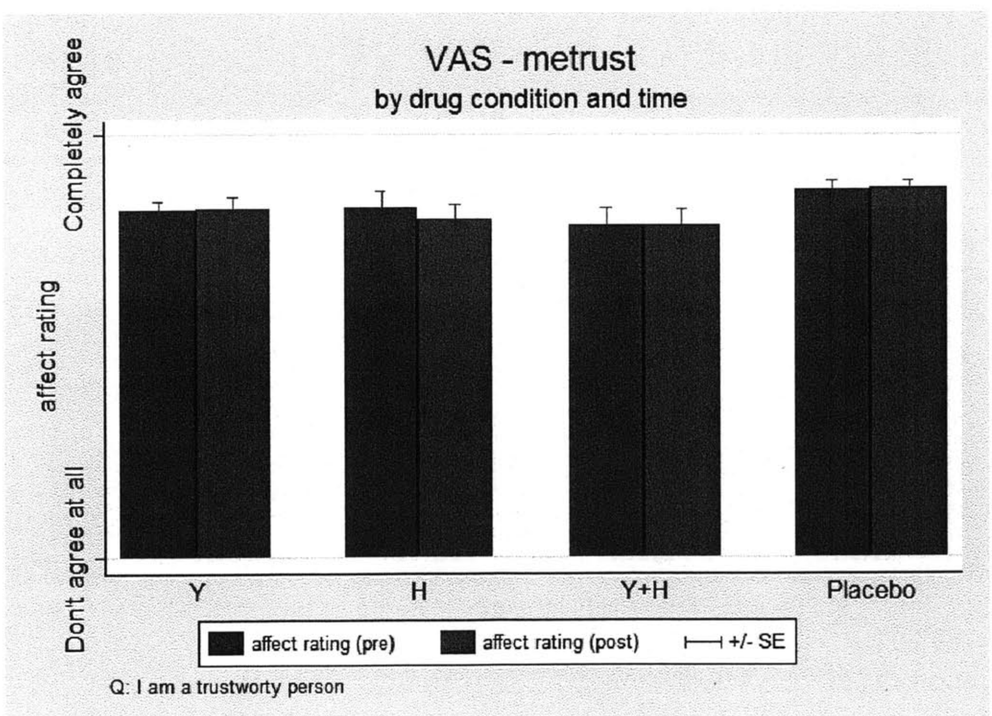

PANAS - jittery
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

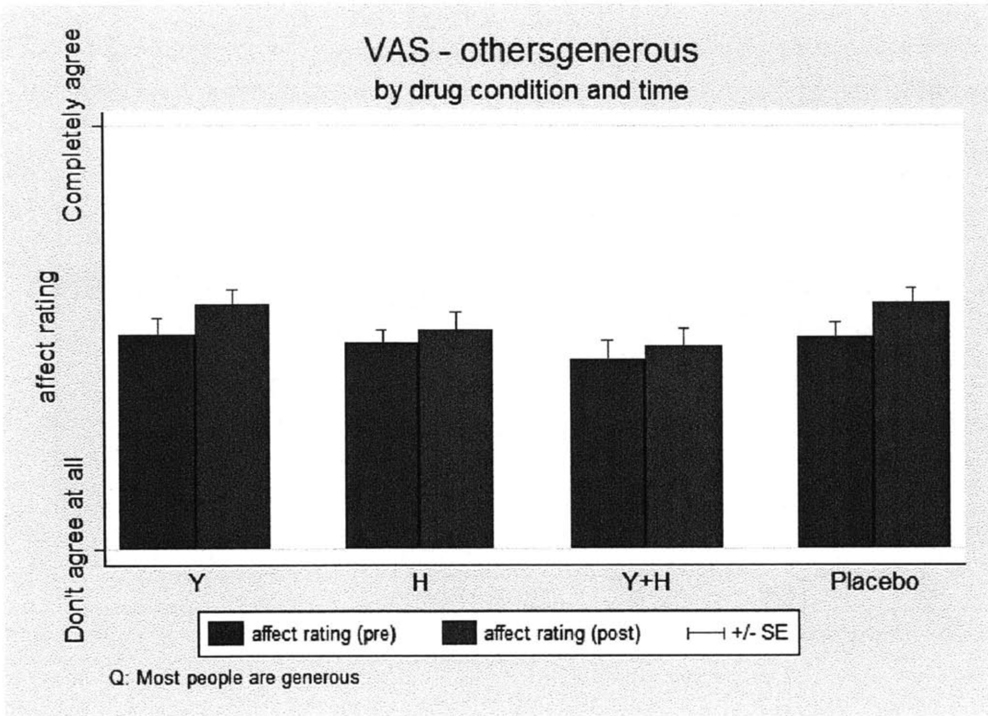

PANAS - afraid
by drug condition and time
affect rating
A little
Not at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE

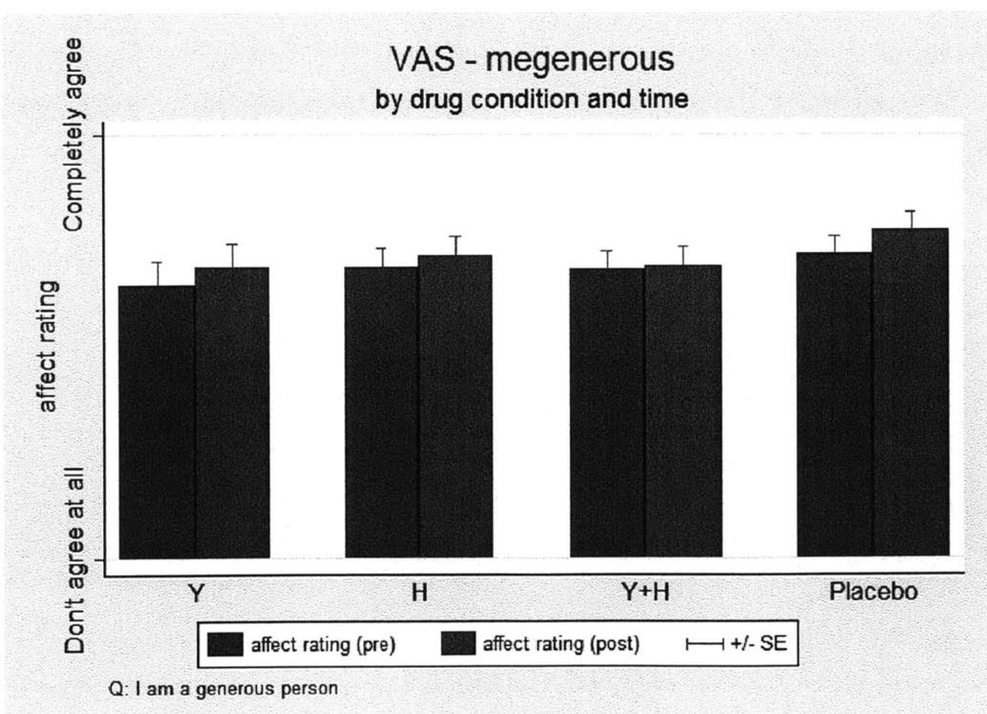

VAS - stressed
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: In this moment, I feel stressed

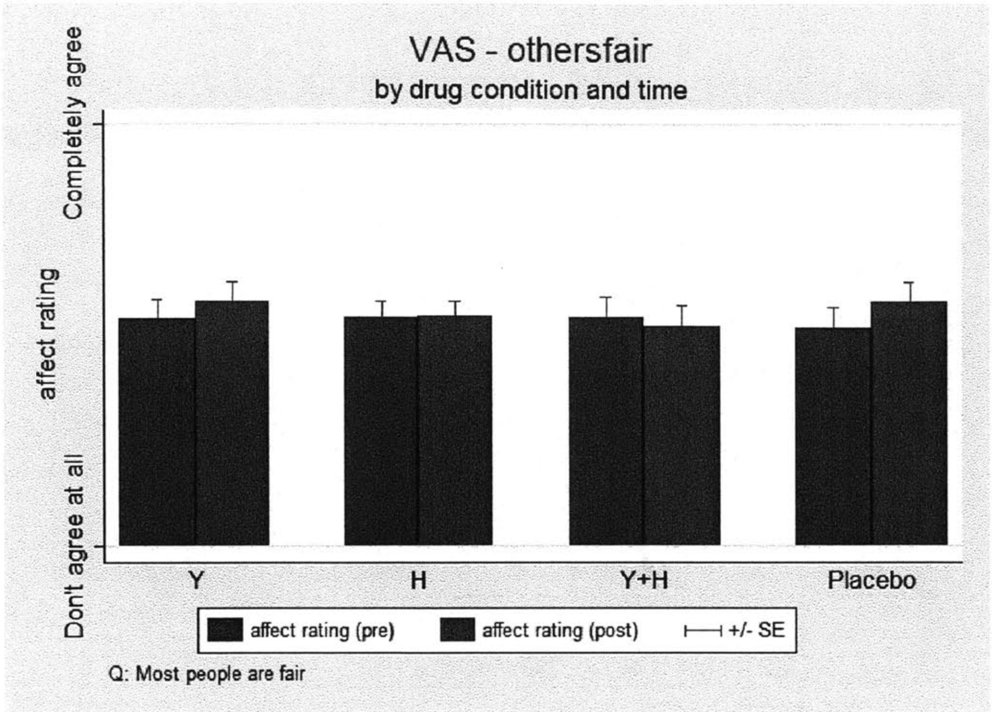

VAS - punishment
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: People who break the rules of society should face severe consequences

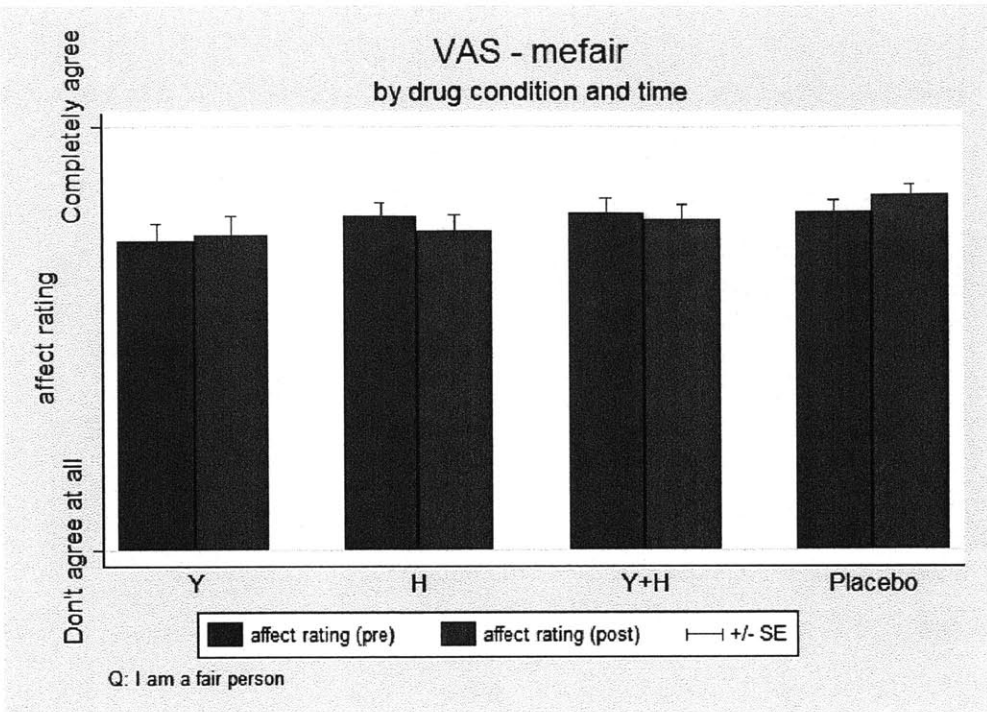

VAS - otherstrust
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: People can generally be trusted

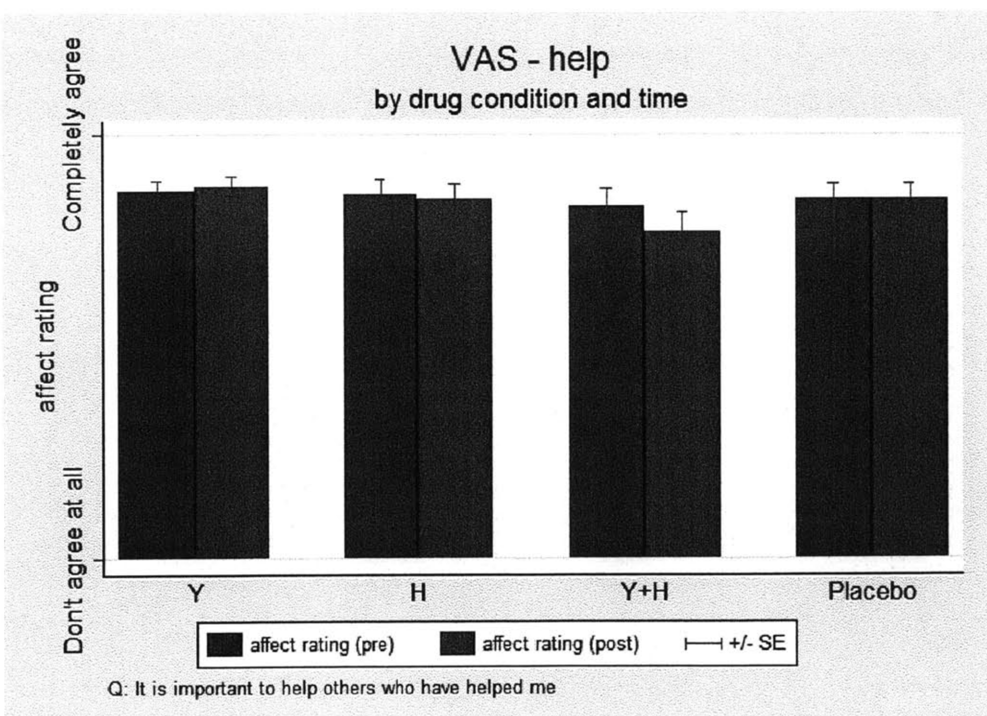

VAS - metrust
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: I am a trustworty person

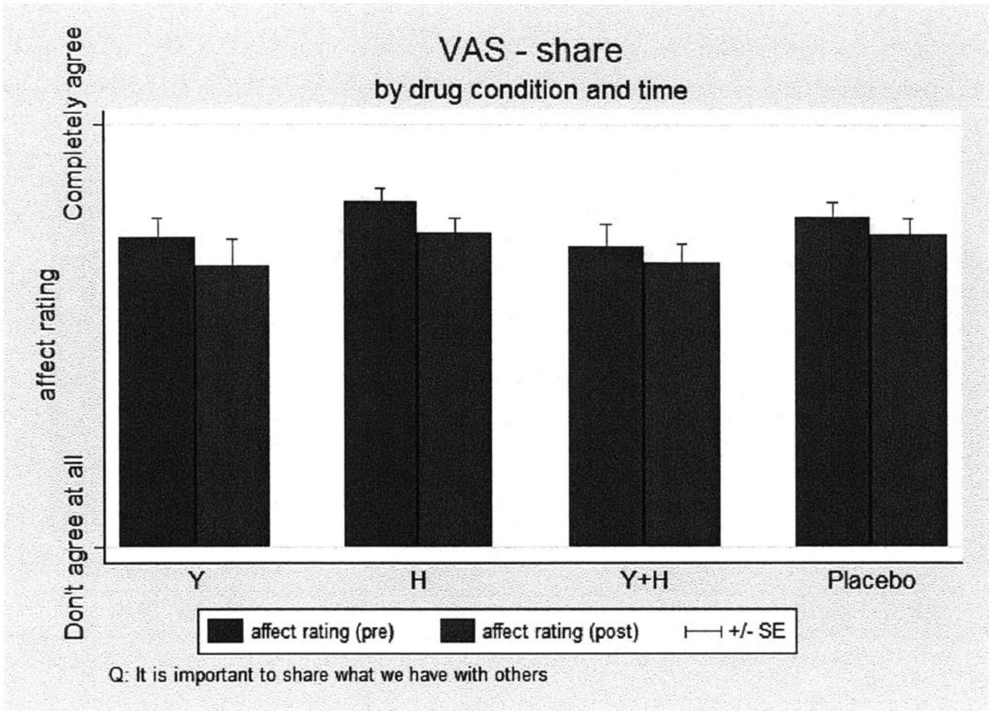

VAS - othersgenerous
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: Most people are generous


VAS - megenerous
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: I am a generous person

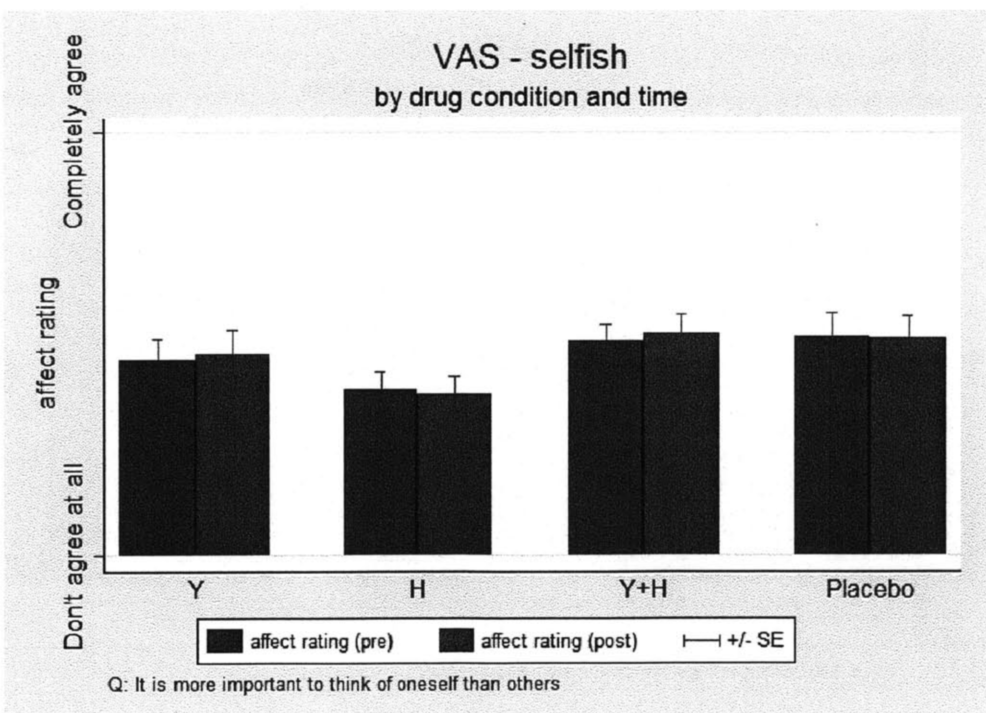

VAS - othersfair
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: Most people are fair


VAS - mefair
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: I am a fair person

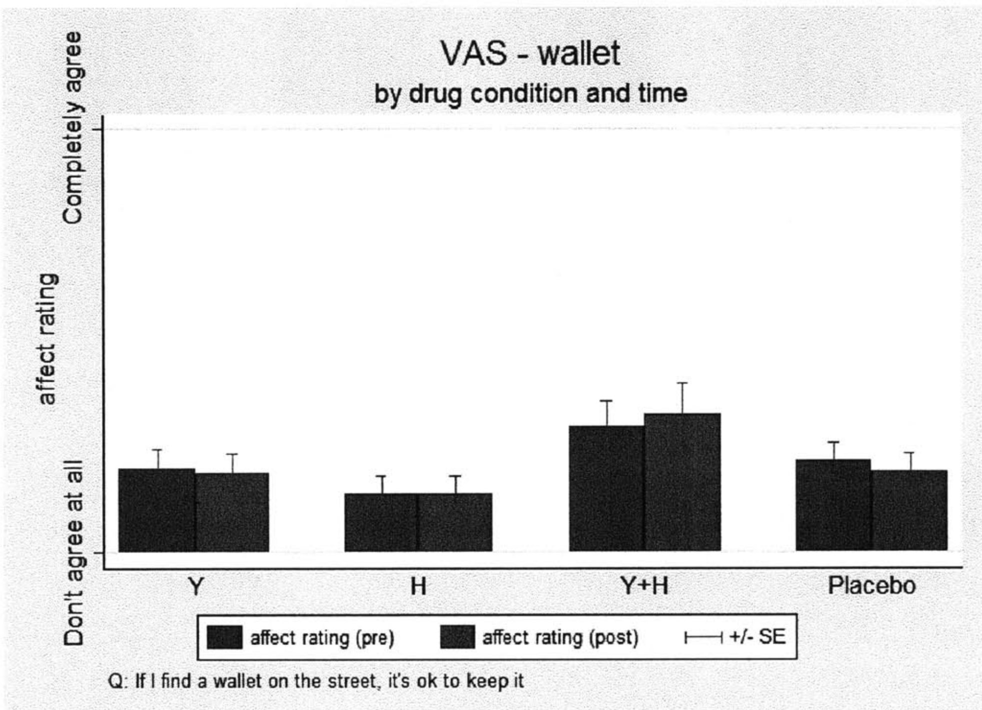

VAS - help
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: It is important to help others who have helped me



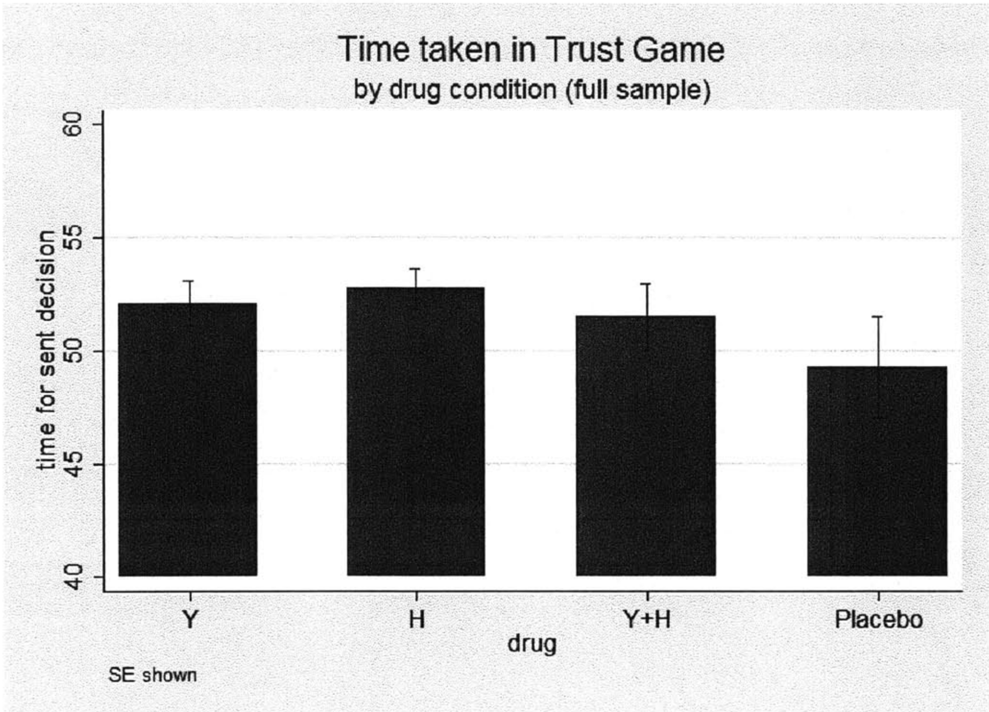
VAS - share
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: It is important to share what we have with others

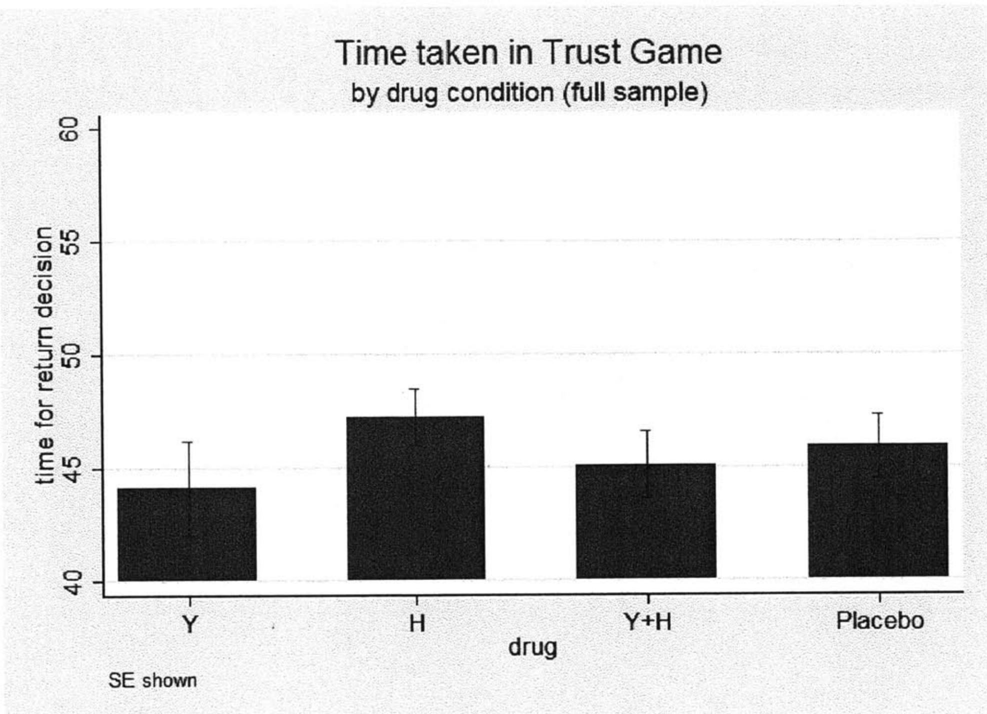


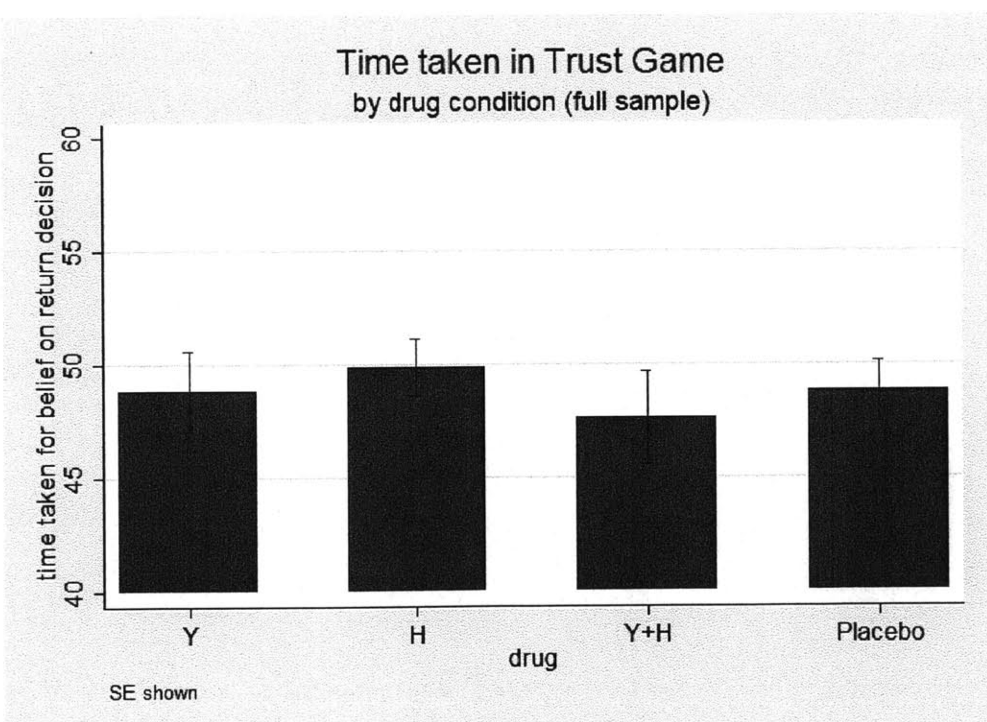
VAS - selfish
by drug condition and time
Completely agree
affect rating
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: It is more important to think of oneself than others

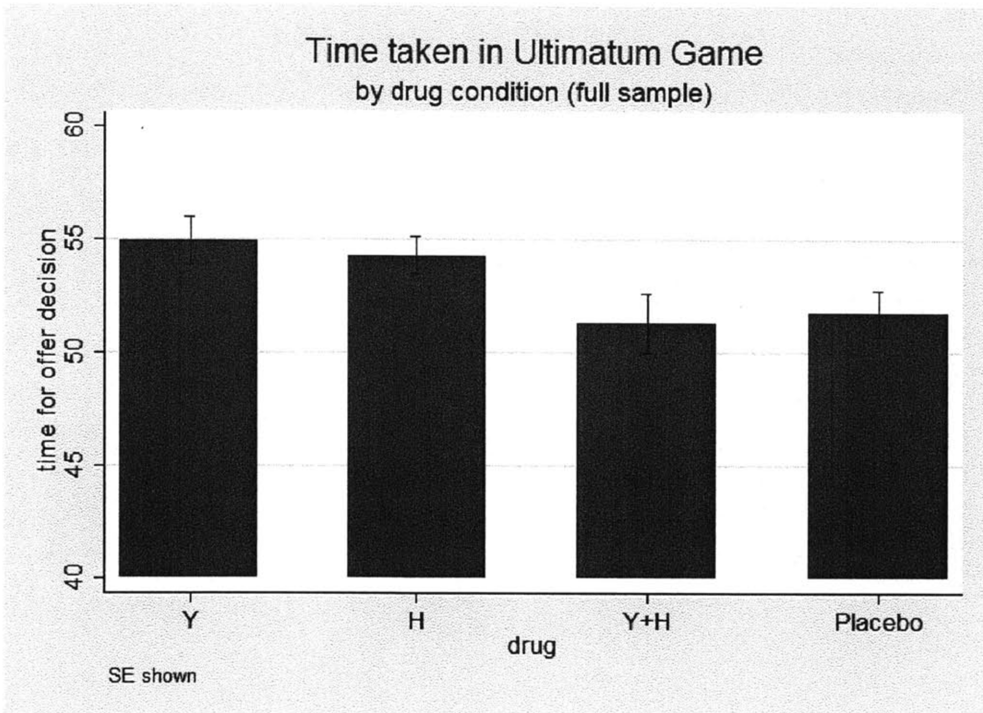

VAS - wallet
by drug condition and time
affect rating
Completely agree
Don't agree at all
Y
H
Y+H
Placebo
affect rating (pre)
affect rating (post)
+/- SE
Q: If I find a wallet on the street, it's ok to keep it

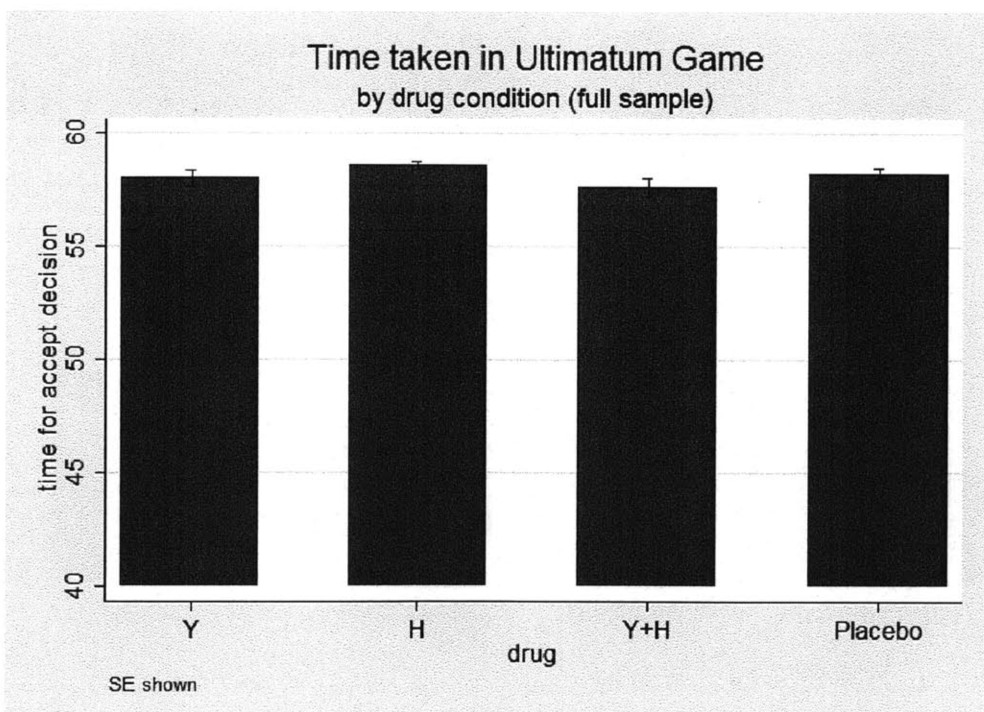
Contemplation Time Figures

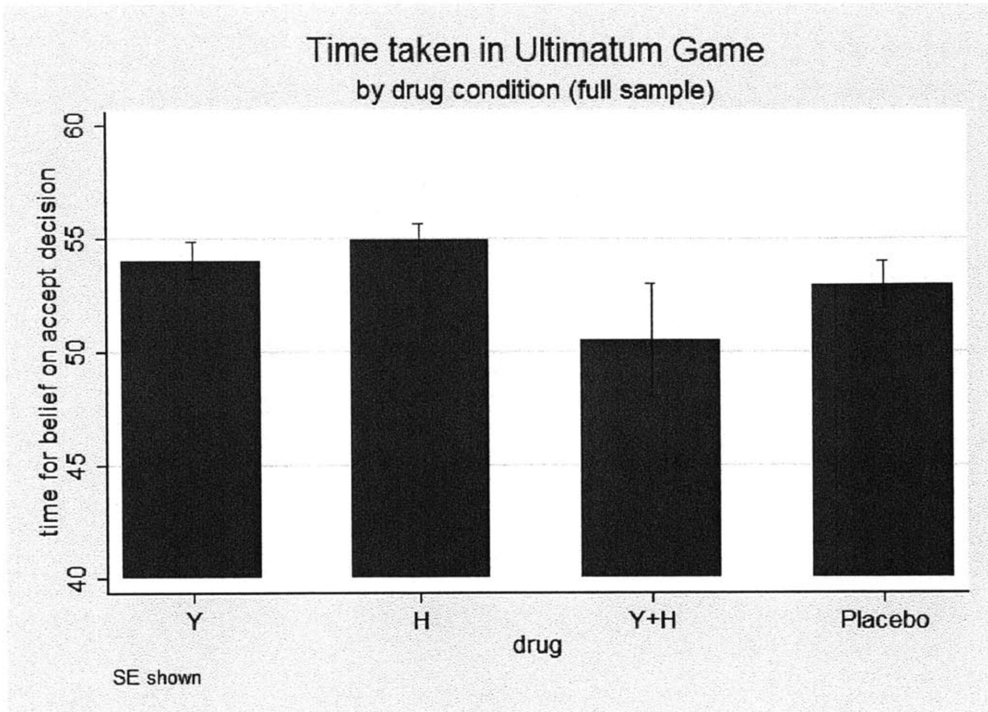


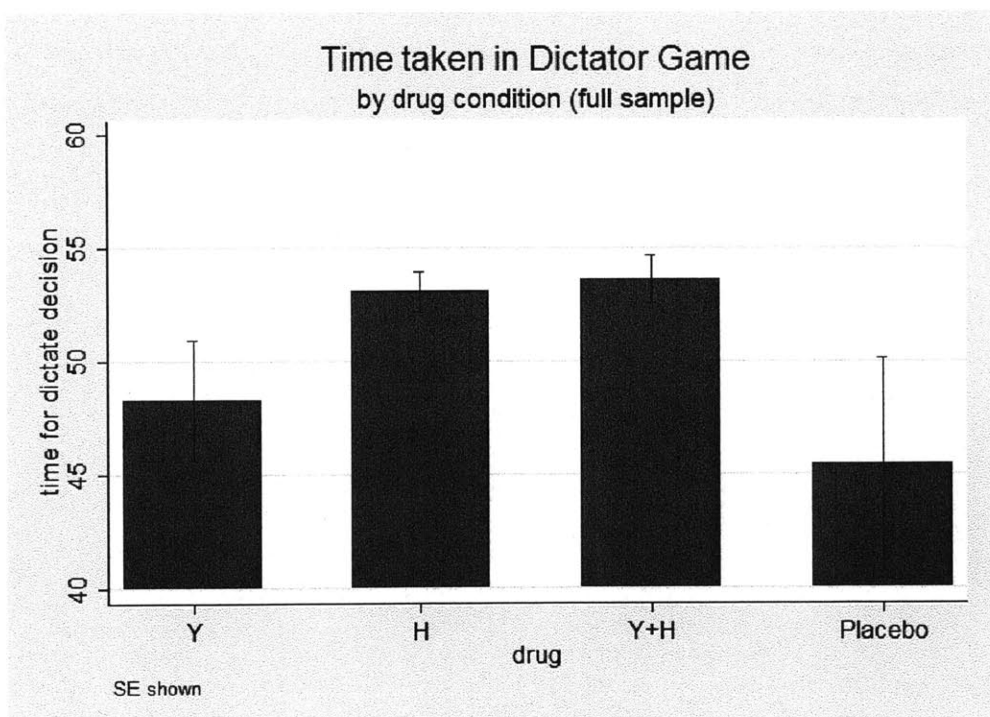

Time taken in Trust Game
by drug condition (full sample)
time for return decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown


Time taken in Trust Game
by drug condition (full sample)
time taken for belief on return decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown


Time taken in Ultimatum Game
by drug condition (full sample)
time for offer decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown


Time taken in Ultimatum Game
by drug condition (full sample)
time for accept decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown


Time taken in Ultimatum Game
by drug condition (full sample)
time for belief on accept decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown


Time taken in Dictator Game
by drug condition (full sample)
time for dictate decision
60
55
50
45
40
Y
H
Y+H
Placebo
drug
SE shown

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